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AIR UNIVERSITY

RADIOLOGICAL DISPERSAL DEVICE PRIMER:
FROM A TERRORIST'S PERSPECTIVE

by

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Biography

Lieutenant Colonel Joel T. Hanson is a student in the Air War College class of 2008 at Maxwell AFB, AL.

Lt Col Hanson attended the United States Air Force Academy, Colorado Springs, CO and was awarded a Bachelors of Science in Management. He also earned a Masters in Business Administration from the University of South Dakota, Rapid City, SD and a Masters in Logistics Management from the Air Force Institute of Technology (AFIT), Wright-Patterson AFB, OH.

After being commissioned from the United States Air Force Academy in 1990, he became an ICBM maintenance officer and was assigned to Ellsworth AFB, SD. He filled a variety of maintenance positions including Electro-mechanical Assistant Branch Chief, Vehicle Control Officer, Missile Maintenance Branch Chief, Wing Programs Manager, and finally as Chief of the Maintenance Support Division during the pioneering Minuteman II weapon system deactivation. Next, he attended AFIT in 1994. Following graduation in 1995, he was assigned to the 576th Flight Test Squadron at Vandenberg AFB, CA as the OIC, Missile Maintenance Operations Center, Support Flight Commander and as the Generation Flight Commander.

Lt Col Hanson was next assigned to the Ogden Air Logistics Center, Hill AFB, UT in 1998 as a Logistics Career Broadener where he held various positions in the Center to give him maximum exposure to wholesale logistics activities. Additionally, he served as the Aide de Camp to the Center Commander. His next assignment in 2001 was as Chief, Logistics and Acquisitions Inspection Policy in the Inspector General Office, Headquarters United States Air Force, Washington, D.C. He also served as the Executive Officer to The Inspector General. Lt Col Hanson then attended Marine Command and Staff College, Quantico, VA. After school, he was assigned to the 90th Maintenance Operations Squadron, Francis E. Warren AFB, WY, in 2004 where he was first the Maintenance Operations Officer and then commander before attending Air War College in 2007.

Lt Col Hanson and his wife Monica have three children, Danielle, Skye, and Hunter.

Introduction

Radiological weapons are a growing threat within the United States. Radiological Dispersal Devices (RDDs), or more commonly referred to as “dirty bombs”, offer terrorists a potential means to inflict major damage to the American economy and psyche. A RDD is defined as a weapon designed to disperse radioactive material over an area using either conventional explosives or more covert dispersion methods such as air currents.¹ A RDD is considered by many experts to be a weapon of choice in that it offers the potential for 9/11-type returns for the relatively low-tech knowledge required to construct and deploy the weapon.

It is clear the American public agrees the RDD threat is real based on the massive growth in information dedicated to the subject on the Internet. A simple Google search conducted in December 2007 incorporating the search term “dirty bomb” coupled with the year 1987 identified 26,200 hits. Ten years later, using the year 1997, identified twice as many hits - 56,600. Another search for 2005 and then 2006 identified 309,000 and 326,000 hits, respectively. In 2007, the number of hits jumps to 620,000.² Clearly, a one year doubling of Internet information related to dirty bombs reveals a heightened awareness of the issue among the public.

U.S. local, state and federal governments appear to agree based on efforts to fund and deploy radiation detection equipment, develop/implement consequence management plans and conduct large scale RDD exercises - all in 2007. Congressional oversight is also higher. Multiple Government Accountability Office reports pertaining to the RDD threat were published

¹ Dana A. Shea, Radiological Dispersal Devices: Select Issues in Consequence Management, Congressional Research Service Report for Congress RS21766 (Washington D.C.: Library of Congress, 7 December 2004), 1.

² A search using another internet search engine, Yahoo, revealed similar proportional results. The number of “hits” for Yahoo were as follows: 1987 - 76,100 ; 1997 - 204,000 ; 2005 - 822,000 ; 2006 - 965,000 ; 2007 - 1,980,000. The exact phrase used in each search was as follows: “dirty bomb” AND [year] (e.g., “dirty bomb” AND 2007).

in 2007. While an abundance of public information covering RDDs is helpful to educate the public, this information is also available to a terrorist intent on attacking the U.S. homeland.

The United States just witnessed the sixth anniversary since the al Qaeda terrorist network executed its 9/11 attack on the World Trade Center and the Pentagon. Its objective was to inflict great American loss of life and economic destruction. The objective was achieved - 2,981 lives lost, \$27.2 billion in direct costs, and over \$500 billion in indirect costs.³ The key question is whether al Qaeda (or any other terrorist network) is planning additional attacks on U.S. soil and if so, what will be its method and where will it attack?

In February 1998, Osama bin Laden, the leader of al Qaeda, issued the following statement, "In compliance with God's order, we issue the following fatwa to all Muslims: The ruling to kill the Americans and their allies - civilian and military - is an individual duty for every Muslim who can do it in any country in which it is possible to do it ... and wishes to be rewarded to comply with God's order to kill the Americans and plunder their money wherever and whenever they find it.". ⁴

Clearly, it must be assumed from this statement that the intent to inflict casualties and economic disaster is a top priority of al Qaeda. The attacks on 11 September 2001 solidified this intent. President Bush noted this intent in his 11 February 2004 address to the National Defense University, "... What has changed in the 21st century is that, in the hands of terrorists, weapons of mass destruction would be the first resort - the preferred means to further their ideology of

³ Statement compiled from two sources:

Robert Looney, "Strategic Insight: Economic Costs to the United States Stemming From the 9/11 Attacks", Center for Contemporary Conflict, (5 August 2002), <http://www.ccc.nps.navy.mil/rsepResources/si/aug02/homeland.asp>.
Final Report of the National Commission on Terrorist Attacks upon the United States, Executive Summary, *The 9/11 Commission Report* (U.S. Government Printing Office), 1-2, http://www.9-11commission.gov/report/911Report_Exec.pdf.

⁴ Ibid., 5-6.

suicide and random murder.”⁵ With the desire to bring recognition to their fatwa, al Qaeda will continue to develop attack scenarios on par or greater than 9/11. A RDD is a likely choice.

Al Qaeda has expressed an interest in acquiring a RDD. In June 2002, the U.S. government arrested José Padilla (a.k.a. Abdullah Al-Mujahir) and alleged he was an al Qaeda operative planning a dirty bomb attack in the U.S.⁶ Ultimately, Padilla was not indicted specifically for planning a RDD attack but was charged with materially supporting a terror group by attending an al Qaeda training camp.⁷ Also, in January 2003, British officials uncovered evidence that al Qaeda had already built a RDD in Afghanistan, however, no concrete evidence has been found to corroborate the initial evidence.⁸ Even though circumstantial, al Qaeda does appear to be interested in building a RDD.

This study will attempt to analyze the subject of RDDs from an al Qaeda terrorist’s perspective. The following scenario provides the platform for the analysis: Osama bin Laden, al Qaeda’s leader, issues a mission-type order to one of his lieutenants to develop a RDD attack plan on U.S. soil. The lieutenant is armed with access to the Internet and a public library. Utilizing nothing but these tools, he will learn everything he can about radiation and RDDs to include radiological source material and the biological, psychological and economic effects that may be expected with a successful attack. Additionally, he will research U.S. strategy and efforts to prevent a RDD attack and will also analyze the U.S.’s interagency response capability. He will quickly learn that New York City is leading the nation in building a RDD defense

⁵ Lewis A. Dunn, “Can al Qaeda Be Deterred from Using Nuclear Weapons?,” Center for the Study of Weapons of Mass Destruction Occasional Paper 3, (Washington D.C: National Defense University Press, July 2005), 1.

⁶ Charles D. Ferguson and William C. Potter, *The Four Faces of Nuclear Terrorism*, (New York, NY: Routledge, 2005), 260.

⁷ It was alleged that Padilla met with two high level al Qaeda leaders, Abu Zubaydah and 9/11 mastermind Khalid Sheikh Mohammed about the idea of building a RDD but was dismissed by the two leaders. Additionally, the U.S. government may have ultimately dropped the dirty bomb charge to conceal coercive interrogation techniques that the Bush Administration may not have wanted revealed in a courtroom. Warren Richey, “Beyond Padilla Terror Case, Huge Legal Issues,” (Boston, MA: The Christian Science Monitor, 15 August 2007), On-line: <http://www.csmonitor.com/2007/0815/p01s08-usju.htm>.

⁸ Ferguson and William C. Potter, *The Four Faces of Nuclear Terrorism*, 260.

structure. Finally, he will develop an understanding of potential U.S. vulnerabilities based on U.S. strategy and prevention efforts. His goal is to develop an attack plan for bin Laden that details the type of radiation material to be used in the RDD, the method of employment and potential high value U.S. targets to strike based on identified vulnerabilities. The paper will conclude with recommendations aimed at preventing this scenario.

Understanding the Basics

A RDD or “dirty bomb” is not a nuclear weapon. A RDD is defined as a weapon designed to disperse radioactive material over an area using either conventional explosives or more covert dispersion methods such as air currents.⁹ Multiple variables will impact the effectiveness of the RDD such as environmental conditions, type and amount of the material, duration of exposure, and method of dispersal.¹⁰ Many experts agree a RDD will not result in massive casualties, however, they believe a RDD has the potential to inflict devastating economic and psychological damage on the U.S. via mass effect.¹¹ Mass effect is defined as an effect inflicting grave destructive, psychological and/or economic damage to the United States.¹² This section will provide a brief primer on radiation and potential radiological sources that would be suited for an effective RDD. Also addressed is the security of radiological sources.

Radiation 101

According to the U.S. Occupational Safety and Health Administration, radiation “includes alpha rays, beta rays, gamma rays, X-rays, neutrons, high-speed electrons, high-speed protons, and other atomic particles; but such term does not include sound or radio waves, or

⁹ Dana A. Shea, Radiological Dispersal Devices: Select Issues in Consequence Management, Congressional Research Service Report for Congress RS21766 (Washington D.C.: Library of Congress, 7 December 2004), 1.

¹⁰ Ibid.

¹¹ Peter D. Zimmerman and Cheryl Loeb, “Dirty Bombs: The Threat Revisited”, Defense Horizons, (Washington D.C., National Defense University, No. 38, January 2004), 1.

¹² Homeland Security Advisory Council: Weapons of Mass Effect Task Force, “Preventing the Entry of Weapons of Mass Effect Into the United States,” (10 January 2006), On-line: http://www.dhs.gov/xlibrary/assets/hsac_wme-report_20060110.pdf.

visible light, or infrared or ultraviolet light.”¹³ Additionally, they define radioactive material as “any material which emits, by spontaneous nuclear disintegration, corpuscular or electromagnetic emanations.”¹⁴

Two additional key terms to define are dose, “the quantity of ionizing radiation absorbed, per unit of mass, by the body or by any portion of the body” and rem, “a measure of the dose of any ionizing radiation to body tissue in terms of its estimated biological effect”¹⁵ Radiation is all around us, but most of it is non-“ionizing” (e.g., radio waves) and does not contain enough energy to harm cells. Ionizing radiation, on the other hand, will damage cells. The higher the dose of ionizing radiation, the more damage will occur in the body to include possible radiation sickness or death. While a low level exposure may not produce a direct clinical effect, any dose the individual receives may increase the lifetime chance of cancer.¹⁶ A radiation dose of 100 rem within a short period of time (hours to days) can cause acute radiation sickness with symptoms such as burns, hair loss, vomiting, diarrhea, and/or blood cell/vascular changes. Death may or may not occur. A dose of 400 rem over a short period of time would cause death in approximately 50% of the cases within a month.¹⁷

Ionizing radiation from radioactive material emits either alpha rays, beta rays, or gamma rays. Alpha and beta particles will not penetrate skin or clothing but pose serious health problems if ingested. High energy gamma photons are highly penetrating and can only be

¹³ “Ionizing radiation. - 1910.1096.” *Occupational Safety and Health Administration, U.S. Department of Labor*, On-line: http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=10098.

¹⁴ Ibid.

¹⁵ Ibid. A rad is also important to define: “a measure of the dose of any ionizing radiation to body tissues in terms of the energy absorbed per unit of mass of the tissue.”

¹⁶ Jonathan Medalia, Terrorist “Dirty Bombs”: A Brief Primer, Congressional Research Service Report for Congress RS21528 (Washington D.C.: Library of Congress, 29 October 2003), 2.

¹⁷ These doses are external doses. If the radiation is inhaled/ingested, the effects are more severe and complicated to calculate. “Terrorism: Guide to Chemical, Biological, Radiological, and Nuclear (CBRN) Weapons Indicators”, (The Director of Central Intelligence’s Weapons Intelligence, Nonproliferation, and Arms Control Center, November 2002).

shielded with dense material such as lead.¹⁸ The strength of a particular source of radiation is determined by the number of nuclei that decay per second. A Curie measures the decay and equals 3.7×10^{10} nuclei decaying per second. A one Curie source is considered large; a 100 Curie source is considered very dangerous.¹⁹ The source material's half-life is the amount of time it takes for 50% of the nuclei to decay. For example, if a one year half life sample has 1000 nuclei, after one year, 500 nuclei will remain, after two years 250 nuclei will remain, and so on. Radiation becomes more intense the shorter the half-life.²⁰ Specific activity represents the number of curies in one gram of radioactive material.²¹ Based on this aforementioned information, only a few radioactive isotopes are ideal for use in a RDD.

Radioactive Material Sources

While hundreds of radioactive isotopes exist, only a handful are suitable to create a RDD such as americium-241, californium-252, cesium-137, cobalt-60, iridium-192, plutonium-238, strontium-90, and radium-226. Of these eight radioactive isotopes, the most commonly accepted as the most effective sources include those with relatively short half-lives²² such as cobalt-60 (5.27 yrs), strontium-90 (29.1 yrs), and cesium-137 (30.17 yrs).²³ All three produce beta emissions with cobalt -60 and cesium-137 also producing gamma emissions. The reason these are effective RDD materials is the balance between relatively long persistence (half life in years versus days - e.g., a material with a half life of hours or days would likely decay to low levels before the material could be used in a RDD)²⁴ coupled with strong radiation emission (as

¹⁸ Peter D. Zimmerman, "Dirty Bombs: The Threat Revisited", 1.

¹⁹ Ibid., 2.

²⁰ Ibid.

²¹ Ibid.

²² "Half-life" is the time it takes for half of the atoms in a mass of a radioactive isotope to decay. The faster the isotope decays will equate to a faster release of radiation which is measured in Curies.

Jonathan Medalia, Terrorist "Dirty Bombs": A Brief Primer, Congressional Research Service Report for Congress RS21528 (Washington D.C.: Library of Congress, 29 October 2003), 2.

²³ "Radioactive Isotopes", Centers for Disease Control and Prevention, On-line, <http://www.bt.cdc.gov/radiation/isotopes/>.

²⁴ Medalia, Terrorist "Dirty Bombs": A Brief Primer, 3.

opposed to non lethal radiation of material with half lives measured in the millions of years - e.g., highly enriched uranium-235 has a half life of over 700 million years).²⁵ Of the three, Cesium-137 is normally found in powder form and is the most effective material for widespread dispersal, however, both Cobalt-60 and Strontium-90 (metallic form) when exploded will be dispersed in dust form.²⁶ The bottom line is all three are potentially effective RDD materials.

Radioactive isotopes are by-products of the nuclear reactor reaction process. The key is their relatively abundant uses in many commercial products such as medical radiation therapy devices, industrial gauges, food irradiators, or as a power source for navigational beacons.²⁷

Figure 1 provides a sample of high-risk radioactive sources and associated radioactivity level.

Source	Radioisotope	Radioactive Level (Curies)
Radioisotope Thermoelectric Generators	Strontium-90 Plutonium-238	20,000 280
Sterilization and Food Preservation Irradiators	Cobalt-60 Cesium-137	4,000,000 3,000,000
Blood/Tissue Irradiators	Cobalt-60 Cesium-137	2,400 7,000
Multi-beam Teletherapy	Cobalt-60	7,000
Industrial Radiography	Cobalt-60 Iridium-192	60 100
Calibration	Cobalt-60 Americum-241 Strontium-90	20 10 2
Level/Conveyor Gauges	Cobalt-60 Cesium-137	5 3-5
Brachytherapy: high and medium dose rate	Cobalt-60 Cesium-137 Iridium-192	10 3 6
Well Logging	Cesium-137 Americum-241/beryllium	2 20
Pacemakers	Plutonium-238	3

Figure 1. High Risk Radioactive Sources²⁸

²⁵ Ibid., 2.

²⁶ Ferguson and William C. Potter, The Four Faces of Nuclear Terrorism, 264.

²⁷ “Radioactive Isotopes”, Centers for Disease Control and Prevention, On-line, <http://www.bt.cdc.gov/radiation/isotopes/>.

²⁸ “International Atomic Energy Agency Safety Standard Series No. RS-G-1.9: Categorization of Radioactive Sources,”

International Atomic Energy Agency, (Vienna, Austria, August 2005), On-line: http://www-pub.iaea.org/MTCD/publications/PDF/Pub1227_web.pdf

The radioactive material in these commercial products are considered sealed sources which refers to radioactive material that has been sealed inside a capsule or is permanently bonded in a solid form. Sealed sources are used to deliver a defined dose of radiation for such purposes as sterilizing food or treating cancer.²⁹ When handled by properly trained individuals, sealed sources are safe. However, if seals are broken, either accidentally or through malicious intent, they become dangerous to the public. The International Atomic Energy Agency (IAEA) website lists five categories these sealed sources are classified into depending on their potential to cause serious health effects:

Category 1 sources could lead to the death or permanent injury of individuals who are in close proximity to the source for a short period of time (minutes to hours). Category 1 sources include: radioisotope thermoelectric generators, irradiators, teletherapy machines, and fixed multi-beam teletherapy machines.

Category 2 sources could lead to the death or permanent injury of individuals who are in close proximity to the source for a longer period of time than for Category 1 sources. Category 2 sources include: industrial gamma radiography equipment and high/medium dose-rate brachytherapy.

Category 3 sources could lead to the permanent injury of individuals who are in close proximity to the source for a longer period of time than Category 2 sources. Sources in Category 3 could, but are unlikely to, lead to fatalities. Category 3 sources include: fixed industrial gauges (level gauges, dredger gauges, conveyor gauges, and spinning pipe gauges) and well logging gauges.

Category 4 sources could lead to the temporary injury of individuals who may be in close proximity to the source for a longer period of time than Category 3 sources. Permanent injuries are unlikely. Category 4 sources include: low dose-rate brachytherapy sources, thickness gauges, portable gauges, and bone densitometers.

Category 5 sources could, but are unlikely to, cause minor temporary injury of individuals. Category 5 sources include X ray fluorescence devices, static eliminators, and electron capture devices.

Figure 2. International Atomic Energy Agency Sealed Source Categories³⁰

Because of decay, at some point a sealed source will no longer function as intended. This may lead the user to improperly dispose of the source rather than take the time consuming and difficult process of proper disposal. Improperly disposed sources are called orphaned sources and are a major concern. The Nuclear Regulatory Commission estimates that there are two

²⁹ “Sealed Radioactive Sources: Uses and Risks,” *International Atomic Energy Agency*, (Vienna, Austria), On-line: http://www.iaea.org/Publications/Booklets/SealedRadioactiveSources/government_uses.html.

³⁰ Ibid.

million licensed sealed sources in the United States but no single organization is accountable to track the location and movement of these sources.³¹ The International Atomic Energy Agency states that just about every country has sealed sources which represent millions of sources and that many are not properly controlled. However, of the millions of world-wide sources, only a small fraction (category 1 or 2 sources that contain the most desirable material for use in a RDD) have the strength to cause serious harm.³² Securing and accounting for these sources remains a top concern for governments world-wide.

Security

Because of poor accountability methods, it is very feasible one could obtain RDD material. Potential RDD material acquisition methods from lowest to highest probability include:

- A national government cooperates in transferring material to a terrorist organization. This is considered of low probability because of the ability to trace the source of the material back to the state actor. Iran and North Korea are believed to be able to produce cobalt-60 sources.³³
- An adversary identifies and locates an orphaned source. Generally lax control measures exist world-wide. An August 2003 U.S. General Accounting Office report stated that there are over 20,000 entities licensed in the U.S. to possess/use radioactive material. The report goes on to say that from 1998 to 2002, there were 1,300 reported incidents of lost, stolen, or abandoned sealed sources.³⁴ Internationally, while there are no concrete numbers, experts believe the number of orphaned sealed sources to be much higher than in the U.S. based on weaker control mechanisms and larger quantities.

³¹ Nuclear Security: Federal and State Action Needed to Improve Security of Sealed Radioactive Sources, (Washington D.C., United States Government Accounting Office, August 2003), GAO-03-084, On-line: <http://www.gao.gov/new.items/d03804.pdf>, 4.

³² “Inadequate Control of World's Radioactive Sources”, International Atomic Energy Agency, (Vienna, Austria), On-line: <http://www.iaea.org/NewsCenter/PressReleases/2002/prn0209.shtml>.

³³ Ferguson and William C. Potter, The Four Faces of Nuclear Terrorism, 272.

³⁴ The report cites numerous examples within the U.S. of orphaned sealed sources. “Nuclear Security: Federal and State Action Needed to Improve Security of Sealed Radioactive Sources,” United States General Accounting Office, August 2003, GAO-03-804.

- An insider at a facility controls material and is blackmailed or bribed to provide it (e.g., in hospitals or food processing plants). Also of note, such an insider might also be able to provide instructions on safe handling of the radioactive material.³⁵
- Adversaries steal radioactive materials from facilities. Many sites containing sealed sources are vulnerable to theft and even more so if combined with the aforementioned insider threat. Of particular concern are facilities located in the former states of the Soviet Union where poor economies coupled with lax security create a ripe environment for theft. For example, in 2003, thieves stole radioisotope thermoelectric generators from three Russian lighthouses. Each radioisotope thermoelectric generator contained millions of curies of material. It was reported the thieves wanted the scrap metal to sell, however, the incident underscores the risk of theft. All radioisotope thermoelectric generators were recovered.³⁶ On 9 October 2007, a government advisory panel recommended the U.S. government should replace more than 1,000 irradiation machines located in hospitals and research facilities because terrorists could use the cesium-137 material inside to make a dirty bomb. Swapping the machines for machines without hazardous material would cost \$200 million over five years but would be worth the expense to keep terrorists from acquiring the most accessible material available to terrorists in the U.S., according to the panel. While the U.S. government may or may not act on this initiative, it illustrates an example of open source information that highlights an insecure sealed source for a RDD.³⁷
- Adversaries use false documents and secure radioactive material by applying for fraudulent licenses. Two General Accounting Office (GAO) investigations revealed serious vulnerabilities. In a March 2003 investigation, the GAO was able to purchase a small quantity of radioactive material over the phone in a foreign country. Using a sample Nuclear Regulatory Commission (NRC) license obtained off of the internet, the GAO was able to produce a fake license. While the radioactivity was identified by Customs and Border Protection officers both times when crossing the border into the United States, the fake NRC license allowed free passage. The border officers had no way of confirming the authenticity of the license.³⁸ In a follow up investigation in July 2007, the GAO incorporated two dummy organizations and using aliases, applied for a Category 4 (low threat) radioactive material license at the Nuclear Regulatory Commission and a license with an Agreement State.³⁹ The

³⁵ Ibid., 272-273.

³⁶ Ferguson and William C. Potter, *The Four Faces of Nuclear Terrorism*, 276.

³⁷ Pamela Hess, “Panel Wants Tighter Radiation Security,” (Washington: Guardian Unlimited, 9 October 2007), On-line: <http://www.guardian.co.uk/world/2007/oct/09/0,-6984049,00.html>.

³⁸ “Dirty Bomb Vulnerabilities”, (Staff Report to Permanent Subcommittee on Investigations: United State Senate, 12 July 2007), On-line: http://hsgac.senate.gov/_files/REPORTDIRTYBOMBVULNERABILITIESFINAL.pdf.

³⁹ “The Atomic Energy Act of 1954 authorizes the NRC to regulate the possession and use of sealed sources through regulatory requirements, licensing, inspection, and enforcement. Section 274 of the Act authorizes the NRC to delegate this licensing, inspection, and enforcement authority to states that agree to regulate their residents’ use of sealed sources. States that enter such contracts with the NRC are commonly called “Agreement States.” After entering into an agreement with the NRC, the respective states then become responsible for regulating the possession and use of radiological materials within their borders. The NRC periodically evaluates the Agreement States’ programs to ensure that they remain compatible with NRC regulations and are generally effective in protecting health and public safety.”

Agreement State effectively prevented authorized access, however, the Nuclear Regulatory Commission after a few faxes and phone calls approved the license and mailed it to a UPS box. Upon receipt of the valid license, the GAO investigators were able to counterfeit and mass produce the license, removing the limits to the amount of radioactive material authorized. Subsequently, they were able to contract with two companies for a dangerous level of material. While they stopped their efforts at this point, in essence, they could have continued and procured more than enough material to produce an extremely effective RDD.⁴⁰

With justifiable concern, Representative Edward Markey (MA) and Senator Hillary Rodham Clinton (NY) introduced and secured passage of an amendment to the 2005 Energy Bill, called the Dirty Bomb Prevention Act. The purpose of this act was to require a cradle to grave national tracking system for sealed sources in order to reduce the risk that terrorists could obtain these materials. After two years of slow rolling the improvement process and two GAO reports that gave the Nuclear Regulatory Commission a “black eye”, compliance progress is being made. As Rep Markey noted, “Congress enacted the ‘Dirty Bomb Protection Act,’ not the “Try Not to Accidentally Lose the Cesium Act,’ The Nuclear Regulatory Commission needs to follow the law to make sure that radiation sources that could be used by a terrorist to build a dirty bomb are kept track of by the federal government.”⁴¹

The Nuclear Regulatory Commission issued a rule into the Register on 8 November 2006 implementing the National Source Tracking System (NSTS). The rule requires Category 1 or 2 sealed source manufacturers to assign a unique serial number to each source. Also, all licensees owning Category 1 or 2 sealed sources are required to enter all movement and tracking of the sources under their control into the secure, web-based Nuclear Regulatory Commission National Source Tracking System. Inventories must be physically verified and reconciled with the

⁴⁰ “Dirty Bomb Vulnerabilities”, (Staff Report to Permanent Subcommittee on Investigations: United State Senate, 12 July 2007), 3. On-line: http://hsgac.senate.gov/_files/REPORTDIRTYBOMBVULNERABILITIESFINAL.pdf.

⁴¹ Ibid.

⁴¹ “Markey and Clinton Push for Tighter Controls on Nuclear Materials that Could Be Used to Make a Dirty Bomb”, (Congressman Ed Markey Web-site, 22 June 2006), On-line: http://markey.house.gov/index.php?option=com_content&task=view&id=1744&Itemid=78.

National Source Tracking System annually. The National Source Tracking System complies with the International Atomic Energy Agency's Code of Conduct on the Safety and Security of Radioactive Sources. Additionally, the National Source Tracking System adds a much needed layer of security and accountability by providing transparency to the tracking of material, the communication of sealed source status to other government agencies, and the ability to conduct improved inspections and investigations.⁴² In addition to the implementation of National Source Tracking System, the U.S. government is implementing other initiatives aimed at securing radiological sealed sources.

The Department of Energy (DOE) through its National Nuclear Security Administration (NNSA) consolidated its radiological threat reduction efforts into the 2004 Global Threat Reduction Initiative (GTRI). The goal of Global Threat Reduction Initiative is to reduce the risk of vulnerable radiation sources by (1) upgrading the physical security of high risk sites, (2) locating, recovering, and consolidating lost or abandoned sealed sources into secure facilities, and (3) advising on the development of the necessary infrastructure to sustain improved security systems.⁴³ From 2002 to March 2007, Department of Energy/National Nuclear Security Administration has secured thousands of radiological sources at 500 facilities in 43 countries and spent \$120 million to secure vulnerable radiological sources and thus preventing a potential acquisition source for a terrorist.⁴⁴ Of note, Department of Energy/National Nuclear Security Administration has secured 1,000 high risk radiological sources from Iraq.⁴⁵ National Nuclear Security Administration also supports the Off-Site Source Recovery Project (OSRP) which is

⁴² "The National Source Tracking System and Interim Inventory", (Washington D.C.: U.S. Nuclear Regulatory Commission), On-line: <http://www.nrc.gov/security/byproduct/nsts.html>.

⁴³ Andrew Bieniawski, "Statement Before the U.S. Senate Homeland Security and Government Affairs Committee Subcommittee on Oversight of Government Management, the Federal Workforce, and the District of Columbia," (Department of Energy, 13 March 2007), On-line: http://www.nnsa.doe.gov/docs/congressional/2007/2007-03-13_Bieniawski_Senate_Homeland_Oversight_GAO_Intl_Rad_Sources.pdf.

⁴⁴ Ibid.

⁴⁵ Ibid.

managed within the Nuclear Nonproliferation Division at Los Alamos National Laboratory. The Off-Site Source Recovery Project is chartered to remove unwanted, abandoned, or orphaned radioactive sealed sources in and around the U.S. Since 1997, it has recovered more than 15,000 sealed sources from 600 sites in 49 states, the District of Columbia, Puerto Rico and multiple foreign countries.⁴⁶

The Environmental Protection Agency also funded a program called Orphan Source Initiative with the Conference of Radiation Control Program Directors (CRCPD), a group of state radiation officials. The steel and recycling industries also cooperated. This initiative provided a mechanism to securely transfer unwanted sealed sources to new owners or provide a cost-effective means to dispose of the material. One example of its success is the securing of 25 1960s vintage Gammator Cesium 137 irradiators located in academic institutions throughout the United States. Each 1,800 pound research machine contained 300 Curies, enough material for a small RDD.⁴⁷

This section revealed, using only open source information, that one can learn a great deal about RDDs such as how radiation works and the type of material that would be ideal to put into the RDD. Also, it was shown where this material is located and based on investigations such as those performed by the GAO, how access to RDD material is possible with minimal difficulty. Finally, a review of government sponsored security initiatives to improve sealed source security was reviewed but logic dictates that the world still has a long road to travel in getting its arm around this problem ... a point not lost from a terrorist's perspective.

⁴⁶ "Off-Site Source Recovery Project, OSRP," Los Alamos National Laboratory, On-line: <http://osrp.lanl.gov/>.

⁴⁷ "Radiation Protection," U.S. Environmental Protection Agency, On-line: <http://www.epa.gov/radiation/source-reduction-management/about.html>.

Radiation Effects

A RDD is not a mass casualty weapon. In fact, most casualties will result from proximity to the high explosive detonation (if present). Instead, RDDs rely on the spread of nuclear radiation, only detectable using special equipment, to accomplish what is generally accepted to be the primary goal of causing the greatest mass effect possible. Again, mass effect is defined as an effect inflicting grave destructive, psychological and/or economic damage to the United States.⁴⁸ A RDD would most likely be employed in an urban center to achieve a mass effect. Overall, the RDD's effectiveness would primarily depend on the amount and type of radioactive material, the amount of explosives to disperse the radiation, and wind speeds.⁴⁹

For example, a study by the Federation of American Scientists calculated that a RDD, using just the Cesium-137 from a medical gauge, detonated at the National Gallery of Art in Washington D. C. would spread radiation over 40 city blocks and the radiation levels would exceed the Environmental Protection Agency contamination limits. Additionally, depending on wind currents, the Capitol, Supreme Court, and the Library of Congress would also fall within the contaminated area.⁵⁰ Decontamination efforts would be lengthy and costly, thus achieving the goal of creating a mass effect. This section will review a real life accident that occurred in Goiania, Brazil to help illustrate the damage that could potentially occur if a RDD weapon was employed. Also, a review of the biological, psychological and economic impacts from a RDD attack would be useful to understand why the threat of a RDD is considered great.

⁴⁸ Homeland Security Advisory Council: Weapons of Mass Effect Task Force, http://www.dhs.gov/xlibrary/assets/hsac_wme-report_20060110.pdf.

⁴⁹ Medalia, Terrorist “Dirty Bombs”: A Brief Primer, 3.

⁵⁰ Ibid., 3-4.

Historical Example

An accidental mishap did occur in Goiania, Brazil in 1987 that highlights the potential effects of radiation contamination. Two scrap metal scavengers broke into an abandoned radiotherapy clinic and removed a Cesium-137 chloride capsule from a teletherapy machine. The International Atomic Energy Agency estimated that the capsule contained 1,375 Curies. The two men took the capsule home where they promptly got radiation sickness. After puncturing the capsule, the glowing blue powder leaked out and due to fascination with the glowing properties, passed the material out to friends and family, some of which was brought to a clinic via a bag on a public bus.⁵¹ The end results were 5 people dead, 151 people with internal contamination, 140,000 people sought medical screening, 85 buildings/home demolished, and a total economic impact estimated in the hundreds of millions of dollars.⁵² While not a terrorist attack, the Goiania incident provides a concrete example of the potential lethality and psychological/economic destruction of a RDD and provides important data to plan an attack on U.S. soil to achieve mass effect.

Biological Impact

The release of ionizing radiation from a RDD attack will not immediately kill many if any people but certainly could raise the chance of negative health effects such as cancer in the future. The biological effects of the radiation exposure would be proportional to the dose received (i.e., the higher the dose, the higher the potential for negative health effects). The dose would be determined by the following variables:⁵³

- Type of radiation (alpha, beta and/or gamma)
- Amount of radiation absorbed by the body

⁵¹ Zimmerman and Loeb, “Dirty Bombs: The Threat Revisited”, 4.

⁵² Brown, “Transcendental Terrorism and Dirty Bombs: Radiological Weapons Threat Revisited”, 17-18.

⁵³ “Fact Sheet on Dirty Bombs,” Nuclear Regulatory Commission, On-line: <http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/dirty-bombs.html>.

- Distance between the individual and the radiation source
- External and/or internal exposure (skin absorption, inhalation, ingestion)
- Length of time exposed to the radioactive material

The key protection considerations after a RDD attack are to minimize the time of exposure to the radiological material, maximize the distance from the material, and maximize shielding to minimize external radiation or from inhaling the radiation.⁵⁴

It is important to understand that radiation is constantly around us. Natural background radiation exposure from all sources per year is 300 milli-rem (mrem)/year (0.3 rem/year).⁵⁵ The Environmental Protection Agency (EPA) considers 100 mrem per year beyond normal background radiation acceptable. Medical x-rays, for example, provide a dose of approximately 10 mrem per scan.⁵⁶ Health physicists generally agree that out of 10,000 people receiving 1 rem of ionizing radiation in small doses over a lifetime, about 5 or 6 of the 10,000 will develop cancer as a result of the radiation. Consider that the normal cancer rate for a population of 10,000 is 2,000, this additional ionizing radiation adds a small .005 percent chance to the lifetime risk of getting cancer.⁵⁷

If a RDD attack used Cesium chloride and this radioactive material was dispersed using conventional explosives, for illustration purpose, the dose rate for one Curie of cesium chloride at one meter is 0.4 rem/hour. If someone stood by this source for one year, he would get a dose of 3,500 rem. However, during a RDD attack, people will take protective measures, limiting overall external exposure. Potential internal exposure from inhaling dust containing alpha particles would be much more serious since the body's tissues would receive constant irradiation

⁵⁴ Ibid.

⁵⁵ Peter D. Zimmerman, “Dirty Bombs: The Threat Revisited”, 7.

⁵⁶ “Radiation Protection: Health Effects,” U.S. Environmental Protection Agency, On-line: http://www.epa.gov/radiation/understand/health_effects.html.

⁵⁷ Ibid.

from the inside. Additionally, proper decontamination would be important since anyone coming into contact with the individual or his human waste would be exposed to the radiation.

The key point is that those individuals close enough to a RDD attack to receive a dose of ionizing radiation (50-100 rem) that would cause acute radiation sickness such as vomiting, hair loss and possible death would probably be killed first by the explosion. Those surviving the blast would be exposed to much lower doses due to the dispersion of the material. Obviously, the stronger the RDD in terms of the number of curies of material used, the greater the dose rates in a larger area. While exposure will not paralyze the population, fear of the radiation certainly may have a serious detrimental effect on the population.

Psychological Impact

For the majority of people involved in a RDD attack, the risk of developing cancer later in life due to the RDD's radiation would be small ... comparable to the health risk of smoking cigarettes or a high fat diet.⁵⁸ While the actual physical risk would be small, it is the psychological risk experts worry about. For most people, the fear of the unknown as a source of danger is real and since radiation cannot be seen nor felt, it produces elevated fear levels if exposed to it even in the slightest amounts. For government officials, managing the public's fear may be the most difficult task following a RDD attack.⁵⁹

Immediately following a chemical, biological, or radiological attack, evidence suggests that the public will not panic. On the contrary, evidence from recent attacks such as the 1995 sarin attack in Japan, 9/11, the 2001 anthrax attacks in the United States, and the 2005 London bombings suggest that people tend to remain calm and in fact, that populations are fairly resilient

⁵⁸ "Dirty Bomb", Wikipedia, On-line: http://en.wikipedia.org/wiki/Dirty_bomb.

⁵⁹ Ibid.

to an attack.⁶⁰ This author's first hand knowledge of an orderly Pentagon exit after the 9/11 attack confirms this notion. The real area of concern stems from increased psychological disorders developing within the population following an attack.

Studies show that approximately 75% of a population exposed to a nuclear detonation will suffer some form of psychological distress such as loss of sleep, inability to concentrate, or social withdrawal.⁶¹ Additionally, a strain on medical facilities will likely not occur from those that are physically hurt from a RDD attack but from those individuals requiring psychosocial support in the days, weeks, and months following the attack. Those individuals who were directly exposed to radiation as well as their friends and family suffer the highest rates of post-traumatic stress disorder which include symptoms such as anxiety disorders, depression and increased irritability.⁶² This ongoing psychological effect caused by a silent and odorless threat called radiation is exactly how a terrorist will exploit the public's general fear of the unknown and affect not only the population directly exposed but also future generations.

Incidents such as the Russian Chernobyl accident in 1996 or Three Mile Island continued to negatively impact the surrounding communities for years after the radiation release. In fact, studies of communities affected by the release of radiation show that psychosocial stress such as long-term stress elevations and heightened perception of risk remain high for six years following the release of radiation and do not return to normal until the 10 year mark.⁶³ As another example, the Goianians present during the 1987 accident were shunned and isolated from many

⁶⁰ Ben Sheppard, G James Rubin, Jamie K Wardman, and Simon Wessely, "Terrorism and Dispelling the Myth of a Panic Prone Public," *Journal of Public Health Policy* 27, no. 3, 2006, 223.

⁶¹ Jamie K. Waselenko et al., "Medical Management of the Acute Radiation Syndrome: Recommendations of the Strategic National Stockpile Radiation Working Group," *American College of Physicians* 140, no. 12, 1037-1051, 15 June 2004, On-line: <http://www.annals.org/cgi/content/full/140/12/1037> (accessed 3 February 2008).

⁶² Ibid.

⁶³ "Radiation Exposure from Iodine 131 Physiologic Effects," Department of Health and Human Services: Agency for Toxic Substances & Disease Registry, On-line: http://www.atsdr.cdc.gov/csem/iodine/physiologic_effects.html (accessed 3 February 2008).

other Brazilians for years after the event, precisely because of the irrational psychological fear that those exposed Goianians continued to pose a radiation threat to others. Yet another example of the social consequence of radiation exposure occurred with the men and women exposed to the nuclear blast in Nagasaki and Hiroshima. They were looked at as “damaged” and often shunned for marriage because of the perceived potential for “damaged genes.”⁶⁴ The lesson to be learned is that radiation fear may cause a greater impact than the actual physical injury from a RDD attack. This, in turn, could cause a significant increase to the overall economic damage.

Economic Impact

As previously mentioned in his 1998 fatwa, one of Osama bin Laden’s goals for al Qaeda is “to kill the Americans and plunder their money wherever and whenever they find it.” There is no argument that the economic effects from 9/11 damaged not only the U.S. economy but the world’s economy. Bin Laden’s ultimate goal may be to acquire and detonate a nuclear weapon on American soil, however, that goal may still be years away due to the difficulty obtaining fissile material, the technical difficulty assembling a nuclear weapon, and the transportation barriers to be overcome. A RDD offers the potential for commensurate economic damage on par with a crude nuclear weapon but an adversary does not have the same kind of technical challenges in constructing a RDD that he confronts in building a nuclear explosive device.

In 2005, researchers at the Pacific Northwest National Laboratory (PNNL) were commissioned by the Department of Homeland Security to analyze the potential costs associated with the decontamination effort after a nuclear or radiological attack on American soil. The Pacific Northwest National Laboratory employed two models to estimate costs: the Federal Reserve Bank of New York Study of the September 11 attack and the Sandia National Laboratories RadTran V Economic Model. Scenarios developed included an attack of either a

⁶⁴ Ibid.

0.7-kiloton (kT), 13- kiloton, or 100- kiloton nuclear weapon or a 10,000 Curie cesium RDD in five cities ranging in population density from Lukeville, AZ to New York City. Another key variable considered was the decontamination standard ranging from the Environmental Protection Agency's Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) dose limit of 15 mrem/year to the Nuclear Regulatory Commission's established dose limit for workers of 5 rem/year. The Pacific Northwest National Laboratory's model included estimated costs of decontamination to include disposal of contaminated material, decommissioning/rebuilding structures that cannot be cleaned below selected limits, cost of relocating people in the contaminated area, and the indirect costs associated with lost business, lower property values, loss of productivity from lost earnings, and loss of tourism.⁶⁵ The results were staggering.

A 0.7 kiloton detonation in New York City would cost approximately \$2.5 trillion to decontaminate to the 15 mrem/year limit and approximately \$500 billion to decontaminate to the 5 rem/year limit. The open source on-line data did not provide specifics for the 10,000 Curie cesium RDD scenario, however, the on-line source did provide an estimated cleanup cost of \$24 billion/km² for high density urban areas of greater than 10,000 people/km².⁶⁶ While the exact decontamination costs would depend on multiple variables, it is highly probable that a RDD of 10,000 Curie in a highly dense area such as Times Square where property values exceed \$1,000/ft²⁶⁷ would certainly run into the hundreds of billions if not trillions of dollars. The Goiania example provides the only actual data to calculate impacts to an area and in the end, for

⁶⁵ "Thinking about the unthinkable: Economic consequences of a nuclear attack," (Pacific Northwest National Laboratory, 27 January 2006), On-line: http://environment.pnl.gov/accompproline/prodline_detail.asp?id=540.

⁶⁶ Ibid.

⁶⁷ Michael Stoler, "Five Times Square to be Sold; Deutsche Bank Plans to Sell 60 Wall St", (New York, NY, The New York Sun, 26 September 2007), <http://www.nysun.com/article/42310>.

a 1,375 Curie event, over 3,500 m³ of radioactive waste⁶⁸ was removed in an area that pales to the building density of Manhattan. The bottom line is the potential exists for massive economic damage to the U.S. economy if a RDD attack was successful in a densely populated area. While most of the 9/11 cost of recovery was paid by insurance, a RDD attack is a specifically excluded risk in almost all U.S. insurance policies. Thus, the U.S. government would be required to step in to facilitate economic recovery to prevent the second and third order economic effects resulting from the lack of RDD insurance.⁶⁹

This section discussed radiation impacts from a RDD attack. Based on information learned from a real life example and expert opinion, the greatest impact from a RDD attack will not be biological in terms of mass casualties but a mass effect from the economic damage due to contamination and the possible paralysis of the nation due to public fear of radiation contamination. Preventing and responding to a RDD threat is a key responsibility of authorities responsible for U.S. homeland security.

Homeland Security

In 2005, Senator Richard G. Lugar (IN) commissioned a survey, sending a questionnaire to 132 scholars, policy makers, diplomats, and technical experts devoted to the task of WMD non-proliferation. Eighty-five individuals responded and concluded that the risk of a WMD attack somewhere in the world is real and increasing with time. Concerning a WMD attack, the results indicated that a RDD attack is the most likely scenario. Asked the likelihood of a RDD attack in the next five and ten years revealed the following: in the next five years, the median and average affirmative responses were 25% and 27.1%, respectively. Over 10 years, the

⁶⁸ Zimmerman and Loeb, “Dirty Bombs: The Threat Revisited”, 4.

⁶⁹ Ibid.

median and average affirmative responses were both 40% ... twice as high as the estimate for either a nuclear or biological attack.⁷⁰

After 9/11, America had a wake up call in terms of its vulnerability to a terrorist attack on American soil and took aggressive action to reorganize government structures and processes to prevent further attacks. This section reviews the U.S.' post 9/11 strategy to prevent terrorism followed by a look at the U.S.' preparedness to handle a RDD attack utilizing an interagency response. As a likely target for a RDD attack, New York City is leading from the front and taking proactive measures to actively combat the possibility of a RDD attack. A review of these efforts will help frame this section's last topic of potential U.S. vulnerabilities that still exist that may be exploited by a RDD attack.

U.S. Terrorism Prevention Strategy

Following the 9/11 attack, America realized it must do much more to protect its homeland from terrorism. The U.S. responded aggressively with resolve to implement sweeping organizational changes to better prepare itself for a Global War on Terror and ultimately prevent further terrorist attacks on American soil. Two key concepts emerged as the focus: homeland defense and homeland security. Homeland defense is defined as the protection of U.S. sovereignty, territory, domestic population, and critical defense infrastructure against external threats and aggression or other threats as directed by the President, pursuant to his authority as the Commander in Chief.⁷¹ Homeland security is defined as a concerted national effort to prevent terrorist attacks within the United States, reduce America's vulnerability to terrorism,

⁷⁰ "The Lugar Survey on Proliferation Threats and Responses," (Washington D.C., Senator Richard G. Lugar, June 2005), On-line: <http://lugar.senate.gov/reports/NPSurvey.pdf>.

⁷¹ Col Merrick E. Krause and Dr. Jeffrey D. Smotherman, "An Interview with Assistant Secretary of Defense for Homeland Defense Paul McHale," *Joint Forces Quarterly*, no. 40 (1st quarter, 2006): 10.

and minimize the damage and recover from attacks that do occur.⁷² The intersection of both concepts is key to reorganization efforts.

Since 9/11, nearly all national and departmental documents cite homeland defense as the Nation's highest priority because the ultimate role of the Department of Defense is to protect the American people.⁷³ In June 2005, the DoD published its *Strategy for Homeland Defense and Civil Support*. This document identifies the terrorist threat as one that uses asymmetric means to penetrate our defenses in order to attack our citizens, economic institutions and physical infrastructure. To secure the United States from a terrorist attack, the strategy details an active, layered approach to defense focused on a global, seamless integration of U.S. capabilities in the forward regions of the world, the global commons of space and cyberspace, in the geographic approaches to U.S. territory, and within the United States - a defense in depth.⁷⁴

In 2002, the United States created a geographic combatant command, Northern Command (NORTHCOM), to conduct warfighting within the homeland defense area of responsibility (essentially the United States, Canada, and Mexico) and to provide civil support to lead Federal agencies when civilian authorities are overwhelmed or a unique Department of Defense capability is required.⁷⁵ The civil support function provides an important capability for homeland security.

As part of the Homeland Security Act of 2002, a lead agency for preventing attacks within the United States was created on 1 March 2003 called the Department of Homeland Security (DHS). This department consolidated a patchwork of 22 federal organizations chartered to secure the United States. The new department provided unity of effort and improved

⁷² Ibid.

⁷³ Ibid.

⁷⁴ Strategy for Homeland Defense and Civil Support, (Washington D.C.: Department of Defense, June 2005), 1-2.

⁷⁵ Col Merrick E. Krause and Dr. Jeffrey D. Smotherman, "An Interview with Assistant Secretary of Defense for Homeland Defense Paul McHale," 12.

command and control of 180,000 men and women dedicated to homeland security. In October 2007, the Department of Homeland Security updated its cornerstone document, The National Strategy for Homeland Security. The strategy focuses U.S.'s effort on four goals:⁷⁶

- Prevent and disrupt terrorist attacks
- Protect the American people, critical infrastructure, and key resources
- Respond to and recover from incidents that do occur
- Continue to strengthen the foundation to ensure long term success

Ultimately, the strategy leverages the strengths and capabilities from all levels of government, private and non-profit sectors, communities, and individual citizens to achieve its goals.⁷⁷ To better accomplish unity of effort, the Department of Homeland Security developed the National Response Plan (NRP) in January 2005.

The National Response Plan establishes a singular approach to domestic incident management to prevent, prepare for, respond to, and recover from terrorist attacks, major disasters, and other emergencies. This plan, in conjunction with the National Incident Management System (NIMS), provides the structure and operational direction via a combination of Federal, State, local, tribal, private-sector, and nongovernmental entities to respond to an Incident of National Significance (INS) such as a RDD attack. The basic premise of the National Response Plan is that incidents are handled at the lowest jurisdictional level possible but as lower levels are overwhelmed, additional support is mobilized up to and including all instruments of national power to include Department of Defense resources.⁷⁸ The bottom line is that the United States has made much progress in addressing the threat terrorism poses to its homeland security.

⁷⁶ National Strategy for Homeland Security, (Washington D.C.: Department of Homeland Security, October 2007), 1.

⁷⁷ Ibid.

⁷⁸ "Statement of the Honorable George W. Foresman, Under Secretary for Preparedness," U.S. Department of Homeland Security, Commission on the National Guard and Reserves, 13 December 2006, p. 2, On-line: www.dhs.gov/xnews/testimony/testimony_1166567952901.shtm.

Detecting, deterring, preempting and defending against potential terrorist attacks is the highest American priority but how prepared is America to respond to a terrorist attack such as a RDD?

U.S. Preparedness / Interagency Response

As mentioned in the introduction, the number of Google hits associated with a RDD or dirty bomb exploded in 2007 to 620,000 versus just 326,000 in 2006. This growth in information available on line is helpful in educating Americans and indicates as a nation, the United States is concerned about the subject and is taking action to prepare to respond to a RDD attack. The key to preparing a nation for a RDD attack is to have solid plans in place to guide and direct, in a coordinated effort, the numerous agencies tasked to provide a particular response capability. The National Response Plan and the National Incident Management System provide the framework to provide timely, organized multi-agency incident command and control of federal support to state, local, and tribal officials. Exercising these plans is also important to identify seams and gaps in response capability. As directed in the December 2003 Homeland Security Presidential Directive 8, the President's National Preparedness Goal included national planning exercises.⁷⁹ The result was 15 congressionally-mandated National Planning Scenarios to exercise the nation's ability to respond to a wide range of major incidents from natural disasters to terrorist attacks.⁸⁰

National Planning Scenario 11 deals specifically with a RDD attack and was exercised October 2007 as part of the Nation's terrorism preparedness exercise program. Called Top Officials 4 (TOPOFF 4) and sponsored by the Department of Homeland Security, over 15,000 key officials from all levels of government and the private sector (from Cabinet Secretaries to

⁷⁹ "Homeland Security Presidential Directive / HSPD-8 - National Preparedness," The White House: Office of the Press Secretary, 17 December 2003.

⁸⁰ "Homeland Security: Planning Scenarios," GlobalSecurity.org, July 2004, On-line: <http://www.globalsecurity.org/security/library/report/2004/hsc-planning-scenarios-jul04.htm>

governors/mayors/city managers to fire/emergency management/police/public health responders) played in a full-scale assessment of the Nation's ability to prepare, respond and recover from a RDD attack. The scenario involved successful terrorist RDD attacks in Portland, Oregon; Phoenix, Arizona; and the United States Territory of Guam. Key objectives included:⁸¹

- Incident Management: Testing the full range of the National Response Plan policy and the National Incident Management System capability to respond to a WMD
- Public Information: To practice the importance of information dissemination via media sources to calm and inform the public
- Evaluation: To identify lessons learned and best practices for future improvements

The TOPOFF 4 Exercise was constructed based on plausible research on terrorist organization capabilities and news events reported since 9/11 to provide scenario credibility.⁸² This national exercise provided a valuable process for important feedback to identify problems and to practice U.S. response capability.

For a RDD attack, organized and timely consequence management involving the Nation's interagency response is critical. A RDD attack would mobilize response capabilities in multiple federal agencies to include the Department of Energy, the Environmental Protection Agency , the Department of Homeland Security, the Department of Defense, the Department of Justice, the National Guard, the Nuclear Regulatory Commission, the national labs, as well as many others. While a detailed discussion of response capability is beyond the scope of this paper, federal capability specific to a radiation event includes radioactive isotope identification, ground/air contamination mapping, personnel radiation decontamination and medical support.⁸³ This robust

⁸¹ "TOPOFF 4 Frequently Asked Questions," U.S. Department of Homeland Security, On-line: http://www.dhs.gov/xpreprep/training/gc_1179422026237.shtml.

⁸² Ibid.

⁸³ For a detailed review on federal radiological response capabilities, this author suggests the following sources: "Federal Radiological Emergency Response Plan (FRERP)--Operational Plan," 1 May 1996, located on-line at: <http://www.fas.org/nuke/guide/usa/doctrine/national/frerp.htm> or "National Response Plan Nuclear/Radiological Incident Annex," December 2004, located on-line at: <http://hps.org/documents/NRPNuclearAnnex.pdf> or

federal capability to respond quickly to a RDD attack would be critical to calm public fear of radiation and instruct the public on the “way ahead” based on factual information. While the federal organizations are experts in radiation, it will take anywhere from 12 to 48 hours for the capability to arrive, which requires first responders to have a basic understanding of the effects of radiation and a capability to detect radiation.

An excellent instructional aid developed for first responders to a RDD attack by the Conference of Radiation Control Program Directors, Inc. (CRCPD) is the *Handbook for Responding to a Radiological Dispersal Device: First Responder’s Guide - The First 12 Hours*.⁸⁴ Published in September 2006, this 88 page document coupled with their pocket guide provide a valuable reference and training tool for state and local first responders in the event of a radiation incident.

Based on RDD exercise scenarios, a National Response Plan and multiple agencies with radiation expertise, it appears the U.S. federal government is taking the threat of a RDD attack seriously. However, these efforts primarily deal with the consequence management response actions of a RDD terrorist attack. For high risk targets such as New York City, the U.S.’s goal is to detect and prevent a successful terrorist RDD attack. If federal efforts fail, the city’s security measures represent the last layer of defense between the terrorist and the public. New York City appears to be leading the nation in an effort to bolster its “last line of defense” prevention and response capability to a RDD attack should the federal defense in depth fail.

“Combating Terrorism: Federal Response Teams Provide Varied Capabilities; Opportunities Remain to Improve Coordination,” (Washington D.C., United States Government Accounting Office, November 2000), GAO-01-14, On-line at: <http://www.gao.gov/new.items/d0114.pdf>.

⁸⁴ “Handbook for Responding to a Radiological Dispersal Device: First Responder’s Guide - The First 12 Hours,” Conference of Radiation Control Program Directors, Inc., CRCPD Publication 06-6, September 2006, On-line: www.crcpd.org.

New York City: Leading the Way

As one of the country's iconic symbols and the target of numerous terrorist plots since the 1990's, New York City continues to be one of the top targets of terrorists worldwide.

Raymond W. Kelly
Police Commissioner of the City of New York⁸⁵

New York City (NYC) has witnessed at least 19 terrorist plots or actual attacks since 1990 including 12 plots after 9/11.⁸⁶ Why are terrorists so interested in attacking NYC? It is the most densely populated city in North America with over 8.1 million residents within 321 square miles. Expanding outward, the metropolitan area has a population of 18.7 million people. Forty percent of the population is foreign born and it is a hub of international business, finance, media, diplomacy and tourism. The urban area had a gross metropolitan product in 2004 of \$901.3 billion, higher than all but 12 countries in the world.⁸⁷ Based on past attacks and the high threat for continued attacks, NYC is serious about counterterrorism efforts to prevent future attacks. In fact, NYC's Police Department has made the defense against terrorist attacks its number one priority.⁸⁸ A review of NYC's efforts pertaining to the RDD threat would be useful from a terrorist perspective to understand strengths and weaknesses for planning a RDD attack.

In 2002, when NYC Police Commissioner Ray Kelly took the reigns, NYC did not have a counterterrorism program. Today, he has aggressively built arguably the top police counterterrorism unit in the United States that is solely focused on protecting the citizens of

⁸⁵ Mitchell D. Silber and Arvin Bhatt, "Radicalization in the West: The Homegrown Threat," New York Police Department Intelligence Division, 2, On-line: http://www.nyc.gov/html/nypd/downloads/pdf/public_information/NYPD_Report-Radicalization_in_the_West.pdf.

⁸⁶ Richard A. Falkenrath, "Deputy Commissioner for Counterterrorism New York Police Department Statement of Testimony Before the Committee on Homeland Security and Governmental Affairs," United States Senate, 12 September 2006, 10-13.

⁸⁷ Ibid., 1-2.

⁸⁸ Ibid., 3.

NYC.⁸⁹ The NYC Police Department (NYPD) employs 52,000 people with an annual budget of \$3.8 billion.⁹⁰ As a subset, NYC's Counterterrorism Bureau dedicates over 1,000 officers and has a budget in excess of \$200 million annually with an emphasis on training. Over 100 NYC police detectives are assigned to the NY Joint Terrorism Task Force. This task force is granted federal security clearances to be able to work closely with federal intelligence agencies and travels the world to investigate plots and terrorist attacks for clues that may affect NYC.⁹¹

For example, NYC has 10 officers stationed overseas to gather intelligence such as the 2004 Madrid train bombing. NYC was the first law-enforcement agency on the scene and investigative intelligence provided important information to apply to NYC such as improved placement of closed-circuit television cameras and improvements to better blast-proof subway car designs.⁹² The bottom line as explained by the Federal Bureau of Investigation Director Robert Mueller, the NYPD's Counterterrorism Bureau and revamped Intelligence Division are "models for the nation."⁹³ While improved intelligence is vital to preventing terrorist attacks, NYC has focused on numerous other initiatives that cumulatively increase the odds of preventing a RDD attack.

In 2003, the NYPD implemented a program called Operation Atlas which is a detailed security plan with an emphasis on highly visible deployed officers throughout NYC to disrupt terrorist planning. Key surveillance operations include Hercules Team deployments, Critical Response Vehicle (CRV) surges, Transit Order Maintenance Sweeps (TOMS), and Subway

⁸⁹ Kane Farabaugh, "New York City Police Commissioner Says Counterterrorism Top Priority," *Voice of America News*, 19 December 2007, On-line: <http://www.voanews.com/english/2007-12-19-voa25.cfm?rss=united+states>.

⁹⁰ Richard A. Falkenrath, "Deputy Commissioner for Counterterrorism New York Police Department Statement of Testimony Before the Committee on Homeland Security and Governmental Affairs," 2.

⁹¹ Ibid., 3.

⁹² Eben Kaplan, "New York Spurs Counterterrorism Efforts," Council on Foreign Relations, 28 December 2006, On-line: http://www.cfr.org/publication/12312/new_york_spurs_counterterrorism_efforts.html.

⁹³ Richard A. Falkenrath, "Deputy Commissioner for Counterterrorism New York Police Department Statement of Testimony Before the Committee on Homeland Security and Governmental Affairs," 4.

Explosive Trace Detection checkpoints. Hercules Team deployments consist of heavy weapons-equipped teams that patrol high value targets throughout NYC. Critical Response Vehicle surges bring patrol vehicles from each of NYC's 76 precincts during important events as a show of force. Transit Order Maintenance Sweeps provide random sweeps of trains for suspicious packages or persons and are at times conducted in conjunction with screening checkpoints that can detect trace amounts of explosive residue on people or their carry on items.⁹⁴ An added benefit to Transit Order Maintenance Sweeps is that it provides a visible action to help reassure the public that the city of NY is actively engaged in preventing terrorism.

Operation Nexus is a covert intelligence gathering effort to engage with local businesses that may have transactions with terrorists such as car rental agencies, parking garages, or businesses that sell materials used to manufacture explosives.⁹⁵ The goal is to increase counterterrorism awareness when customers appear suspicious. Additionally, the NYPD employs intelligence analysts to process raw information from informants and undercover agents in the field to provide actionable counterintelligence. This key information is used to reduce threats by applying the information to its infrastructure protection program. This program places critical infrastructure into five categories and assigns a team of investigators to cover each area. One task is to conduct threat and vulnerability assessments to high value targets in order to improve security with both the private sector and city agencies.⁹⁶ In July 2005, NYPD implemented “NYPD Shield” to provide a detailed website containing training materials and threat updates via instant messaging to both the private and public sectors.⁹⁷

⁹⁴ Ibid.

⁹⁵ Eben Kaplan, “New York Spurs Counterterrorism Efforts,” On-line: http://www.cfr.org/publication/12312/new_york_spurs_counterterrorism_efforts.html.

⁹⁶ Richard A. Falkenrath, “Deputy Commissioner for Counterterrorism New York Police Department Statement of Testimony Before the Committee on Homeland Security and Governmental Affairs,” 4-5.

⁹⁷ Ibid., 7.

A critical area for concern is Lower Manhattan which arguably is the single most important center in the global financial system including the NY Stock Exchange and American Stock Exchange. In response, NYC implemented the Lower Manhattan Security Initiative (LMSI) with the goal of making this area the most target-hardened area in the nation. Key facets of the Lower Manhattan Security Initiative are based on the city of London's antiterrorism program known as the "ring of steel." The "ring of steel" was built in the early 1990s to deter Irish Republican Army attacks. The program consists of an elaborate system of concrete barriers, checkpoints and thousands of video cameras.⁹⁸ NYC's Lower Manhattan Security Initiative integrates a system of closed circuit surveillance cameras and License Plate Recognition (LPR) readers on all bridges and tunnels going into and leaving Lower Manhattan. Also, steel barriers are employed to block access during high visibility events and to high value targets. Mobile License Plate Recognition readers are attached to helicopters and NYPD vehicles to track and interdict suspect vehicles. The system emphasizes quick response from a central coordination center in the event of a suspected or actual terrorist attack.⁹⁹

Counterterrorism training and an active exercise program are important elements to ensure NYPD officers are better capable to detect potential terrorism and for first responders to be better prepared in the event of a terrorist attack. 9/11 spurred the development of a comprehensive NYPD counterterrorism training curriculum including trends in target selection and attack methodologies; force protection; target hardening; countersurveillance; and terrorist

⁹⁸ Eric Lipton, "To Fight Terror, New York Tries London's 'Ring of Steel,'" The New York Times, 24 July 2005, On-line: <http://www.nytimes.com/2005/07/24/weekinreview/24lipton.html?ex=1279857600&en=8da3a9556c8742e5&ei=5090&partner=rssuserland&emc=rss>.

⁹⁹ Richard A. Falkenrath, "Deputy Commissioner for Counterterrorism New York Police Department Statement of Testimony Before the Committee on Homeland Security and Governmental Affairs," 7-8.

tradecraft.¹⁰⁰ These courses were consolidated into a regional counterterrorism training center in 2002.

In addition to the NYPD, this center provides training to numerous NYC agencies and surrounding police and public safety agencies, the Federal Protective Service, and the U.S. Coast Guard for a total of 130,000 training days since its inception. Coupled with extensive training is an equally extensive exercise program to practice both preventive and response actions for a terrorist attack. Drills are conducted at high visibility sites as well as running daily tabletop exercises with all leadership levels to practice decision-making in response to mock attacks.¹⁰¹ While the aforementioned efforts are critical to an effective terrorist prevention and response program, NYC's effort to install radiation detection equipment is a key capability to identify a pending RDD attack.

As the last line of defense in a defense in depth, the Secretary of the Department of Homeland Defense announced the “Securing the Cities” initiative with NYC being the first city. This initiative involves DHS's Domestic Nuclear Detection Office (DNDO) to develop an integrated, intelligent radiation sensor network emanating from the heart of NYC and extending outward in all directions 50 miles. The goal is to tie all radiation detectors into the Lower Manhattan Security Initiative to minimize the response time from a detected suspicious radioactive source to contact with the radioactive source by a NYPD officer.¹⁰² Following is a look at the various radiation detection initiatives in and around NYC.

In suburban areas out to 50 miles, the Department of Homeland Security and NYPD are supplying law enforcement agencies around NYC with radiation detectors and training to combat

¹⁰⁰ Ibid., 8.

¹⁰¹ Ibid., 9.

¹⁰² Alison Gendar, “Radiation detectors to circle New York City,” Daily News, 9 September 2007, On-line: http://www.nydailynews.com/news/2007/09/09/2007-09-09_radiation_detectors_to_circle_new_york_c.html?ref=rss

a RDD attack by forming a layered ring of protection. A majority of NYC and European terrorist arrests have had links to cells located in the suburban area. Creating a detection system extending out 50 miles is key to providing a defense in depth. Mr. Vayl Oxford, the Domestic Nuclear Detection Office's director states, "Once a nuclear weapon is already in Manhattan, it's too late."¹⁰³ To assist in placing radiation detectors at toll booths, highway choke points, truck stops, weigh stations, rail lines, waterways and in the hands of hundreds of patrolmen and their vehicles, the Domestic Nuclear Detection Office is directing over \$50 million in funds for 2007/08 to purchase equipment and provide training on radiation detection.¹⁰⁴ With only 19 access points into NYC via tunnels and bridges, any vehicle RDD attack will enter NYC through a suburb. While improvements in radiation detection equipment are constantly being fielded, some suburban police officers using older equipment have frequently pulled over motorists only to find the motorist recently ingested a stress test radioactive dye or received radiation treatment.¹⁰⁵ This indicates the program is working, however, too many false positives put a strain on limited resources. The Domestic Nuclear Detection Office is working the challenge of acquiring radiation detection equipment capable of differentiating between dangerous and non-threatening radiation. The Domestic Nuclear Detection Office will evaluate the suburban radiation detector equipment deployment program in 2009 for possible deployment to other major cities.¹⁰⁶

Within NYC, multiple initiatives have been implemented to detect unauthorized radiation sources. In 2005, NYPD asked the Department of Energy to conduct an aerial background

¹⁰³ Corey Kilgannon, "Suburban Police Enlisted to Help Protect the City," (The New York Times, 11 September 2007), On-line:
<http://www.nytimes.com/2007/09/11/nyregion/11secure.html?ei=5090&en=aae39aa4351ceb3e&ex=1347163200&adxnnl=1&partner=rssuserland&emc=rss&adxnnlx=1194609900-GyLCpeEjUHgst0zlTAXsgw>.

¹⁰⁴ Ibid.

¹⁰⁵ Ibid.

¹⁰⁶ Ibid.

radiation survey at a cost of \$800,000 using Department of Homeland Security grant funds.¹⁰⁷

The survey took 4 weeks and over 100 flight hours to complete and employed Department of Energy specially equipped helicopters to map out a baseline of radiation data within the city. In the event of a suspected RDD threat, a new survey could be conducted and compared to the baseline to identify new sources of radiation and thus provide a means to focus investigative efforts and save valuable time. Additionally, after a RDD attack, a comparison of surveys would assist in clean-up efforts.

The Department of Energy estimates millions of dollars could be saved with a baseline survey in the decontamination process by only decontaminating buildings back to pre-existing radiation levels vice removing all traces of radiation. NYC also identified from their survey 80 locations with radiological sources that were unaccounted for and required further investigation. While most “hot spots” were radioactive isotopes at medical facilities, one spot led to the discovery of an old industrial site contaminated with radium. NYC was able to close the site and protect the public from a radioactive isotope known to cause bone cancer.¹⁰⁸

NYPD has acquired over 1,000 hand-held gamma monitors, otherwise known as radiation pagers and has ordered over 1,000 more.¹⁰⁹ These pagers are required for all Sergeants on patrol duty and are also issued to patrolman detailed to critical transit infrastructure such as ferry terminals and the subway system. Additionally, advanced gamma detectors are assigned to specialized units such as the Emergency Service Unit and the Bomb Squad.¹¹⁰ Select patrolman

¹⁰⁷ Gene Aloise, Combating Nuclear Terrorism: Federal Efforts to Respond to Nuclear and Radiological Threats and to Protect Key Emergency Response Facilities Could Be Strengthened, (Washington D.C., United States Government Accounting Office, November 2007), GAO-08-285T, On-line: <http://www.gao.gov/new.items/d08285t.pdf>, 10.

¹⁰⁸ Ibid., 11.

¹⁰⁹ “New York’s terror worries expand to trucks,” Associated Press, (MSNBC: 11 June 2007), On-line: <http://www.msnbc.msn.com/id/19175888>.

¹¹⁰ Richard A. Falkenrath, “Deputy Commissioner for Counterterrorism New York Police Department Statement of Testimony Before the Committee on Homeland Security and Governmental Affairs,” 6.

also carry a Radioactive Isotope Identifying Detector (RIID) that can provide important detail on the type of radiation detected from the pagers and can help focus the response force actions.¹¹¹

Port security is also a priority and NYC has employed radiation detection capability to scan cargo containers entering the New York Container Terminal. The Domestic Nuclear Detection Office has designated NYC as a priority site to receive the next-generation radiation detectors called Advanced Spectroscopic Portal (ASP) monitors. Advanced Spectroscopic Portal monitors will provide the capability to detect radiation and identify the source material such as whether the source is from the potassium in a shipment of bananas or radiation emitted from a material of concern such as uranium or cesium.¹¹² This greater fidelity will greatly reduce the demand for secondary inspections and allow port security to greatly increase the percentage of cargo containers inspected without impacting the flow of commerce.

Clearly, NYC is leading the nation in its ability to protect itself from a RDD attack. Its efforts above and beyond actions taken at the state and federal levels provide a much more hardened target for a terrorist to successfully attack. Initiatives such as its own intelligence gathering counterterrorism unit, Operation Atlas and Nexus, the Lower Manhattan Security Initiative, the Securing the Cities program, and major expenditures on training first preventers and responders are paying big dividends thus far in preventing a RDD attack. However, NYC is just one high value target among hundreds across the United States. While RDD prevention efforts across local, state, and federal levels have been impressive, vulnerabilities still exist for exploitation.

¹¹¹ Glenn Miner, "New York State Police, Homeland Security Office Launch Upstate Radiological Security Program," (New York State Office of Homeland Security: Division of State Police, 18 September 2007), On-line: http://www.security.state.ny.us/ohs_press_releases/Rad%20Detection%20program%209-18-07.pdf.

¹¹² Jon Fox, "DHS considers nuclear detector tests in New York," Global Security Newswire, (Government Executive.com: 15 March 2007), On-line: http://www.govexec.com/story_page.cfm?articleid=36384&dcn=todaysnews.

Vulnerabilities

Securing the United States from a successful RDD attack is a daunting task but true to American ingenuity, it is a task that Americans are addressing in their efforts to prevent terrorism. However, as pointed out previously, many complex issues surround the issue of radioactive material from securing sealed sources, to detecting its movement, to mitigating the consequences of a successful RDD attack. While the U.S. government and private industry have made great strides in securing the nation, there still exist seams and gaps whereby an individual or small group could exploit vulnerabilities that still exist and subsequently craft, transport, and attack U.S. soil using a RDD. Following is an analysis of four vulnerabilities that if not adequately addressed could open the door to a RDD attack.

Security of radioactive sealed sources within the United States. While the International Atomic Energy Agency points out that millions of sealed sources world-wide are either orphaned or held under lax security, it is also true the installation of radiation detection equipment at major transportation hubs around the world is making undetected transport of radioactive material much more difficult. If the goal is to attack the United States on its own soil, the true vulnerability lies with the Nuclear Regulatory Commission's estimated two million licensed sealed sources located within the U.S. border.

Both the March 2003 GAO investigation where investigators used fraudulent methods to purchase radioactive material and the 2007 GAO investigation where investigators successfully set up dummy organizations to obtain a valid license to purchase unlimited amounts of radioactive material highlight that security is negligently weak. Precisely due to the negative results from these investigations, the Nuclear Regulatory Commission is attempting to fix the problem by implementing the web-based National Source Tracking System which is a step in the

right direction. The improvements are slow and are focused only on Category 1 or 2 sealed sources. While Category 3 sources are not dangerous in isolation, combining multiple Category 3 sources would produce enough radioactive material to produce an effective RDD. Understandably, adding Category 3 sources to the National Source Tracking System would greatly increase the administration burden to the Nuclear Regulatory Commission, however, can the nation afford not to?

Clearly the Nuclear Regulatory Commission must be properly resourced to provide the manpower to account for all Category 1 and 2 sources at a minimum and subsequently the National Source Tracking System standards must be rigidly enforced to prevent orphaned or stolen sealed sources. Category 3 sources should be added as soon as practical once Category 1 and 2 sources are tightly controlled. Government inspections will be absolutely critical on an annual basis as a minimum to ensure sound process control mechanisms are in place. The bottom line is the number one vulnerability the United States faces regarding a RDD threat is the poor accountability and control of radioactive sealed sources located within the U.S. borders which could be acquired through any number of means to include theft, locating orphaned sources, or even by using fraudulent documents to obtain a license to acquire radioactive materials.

Available targets exceed available resources to properly defend all targets. The U.S. federal government spends billions of dollars annually to prevent terrorism. NYC is spending hundreds of millions of dollars annually to counter terrorism within its city limits and the metropolitan urban area beyond. Washington D.C., Los Angeles, and Chicago are also spending large sums of money to protect its residents. However, can the same be said of all major cities of a million or more? The answer depends on a number of factors. It depends on how vulnerable

the residents feel. It depends on the potential for catastrophic economic damage or massive casualties based on value of property and population densities. Tough trade off decisions at all levels of government must be made in terms of providing a certain level of security in a fiscally constrained environment. Arguably, NYC is the number one terrorist target but NYC is also arguably the most hardened city against a RDD attack. NYC has received the majority of Department of Homeland Security security grants. But how secure are any of the nine million plus population cities such as Houston, Philadelphia, Phoenix, San Antonio, Dallas, or San Diego or any of the 259 U.S. cities with a population greater than 100,000?¹¹³

Understandably, a RDD attack in any of these cities would not cause the economic damage on a national level that a NYC attack would have but certainly the local economic damage would be catastrophic. However, without the deep pockets of a NYC, these cities must accept a higher level of risk and hope a terrorist group decides against them as a target. Counterterrorism is a costly business, especially in a target-rich environment in the United States.

Radiation contamination standards are too restrictive. As previously stated, the Environmental Protection Agency's Comprehensive Environmental Response, Compensation, and Liability Act dose limit for the general population is 15 mrem/year. The NRC's standard for workers in a radiation environment is 5 rem/year. Statistically, receiving just 1 rem of ionizing radiation in small doses over a lifetime only raises one's chance of getting cancer by .005 percent. The problem lies in educating and convincing the general population that raising the radiation threshold above the Environmental Protection Agency dose limit is safe and acceptable. As shown in the economic analysis, decontamination costs rise exponentially as the standard gets

¹¹³ "List of United States Cities by Population," Wikipedia, On-line: http://en.wikipedia.org/wiki/List_of_United_States_cities_by_population.

tighter. The time to fix this issue is before a RDD attack occurs since rational decisions would come easier. The key is the cost/benefit analysis of the situation.

In a city such as New York, notionally is it worth doubling the dose limit and thus the chance of cancer by a certain percentage to potentially save a trillion dollars in decontamination costs? By properly educating the public on radiation before an attack occurs, the chances are much greater that a rational cost/benefit decision could be made and accepted by the public. A secondary benefit from these types of discussions would be to build public resilience to a RDD attack which would also reduce the overall level of psychological disorders in the general population since the public would have a better understanding of the true risks associated with radiation and how to deal with radiation properly.¹¹⁴ Restrictive dose limits only play into a terrorist's hands by raising the costs of terrorism and thus the incentive for a RDD attack.

Avenues of attack utilizing a small boat or airplane. The simple fact is that America is a free society which values its ability to move about freely. The United States has over 12,000 miles of shoreline and 6,000 miles of border between Canada and Mexico. Additionally, of the nine U.S. cities with a population greater than one million, five are located near a coastline or border with Mexico. While the federal government has spent billions of dollars to secure the airline and seaport cargo industries, the same cannot be said for a potential RDD attack via a small boat or airplane. Both offer a stealthy approach via thousands of routes to major U.S. cities, with a high probability of reaching its intended target. For example, if a RDD was carried by a small plane that took off from a small airport near a major city, it would almost certainly penetrate to its target before authorities could understand and neutralize the threat. Assuming martyrdom is an option, getting caught would not factor into the attack planning ... the only

¹¹⁴ Michael T. Kindt, "Building Population Resilience to Terror Attacks: Unlearned Lessons from Military and Civilian Experience," US Air Force Counterproliferation Center Counterproliferation Papers Future Warfare Series No. 36, (Maxwell Air Force Base, AL: Air University, November 2006), 28-29.

concern for the suicide mission is hitting the intended target. Speaking to the small boat threat, DHS Secretary Chertoff commented that there are more than 17 million operating in U.S. waters, and they range from commercial craft to canoes. He mentioned four specific threats, one being as a launching pad for a RDD attack on the maritime industry or on other critical infrastructure targets.¹¹⁵ However, his solution is applying the same risk-management, partnership, and layering principles already outlined ... but specific to security measures geared to defending against small vessels. He stated that "we need such measures to enhance protection and yet balance our need for freedom of movement, privacy, and economic vitality."¹¹⁶ However, such general statements do not appear to provide much in the way of a specific solution, which is cause for concern.

As for protecting against attacks by small aircraft, NYC, for example, has approximately 2,000 general aviation airfields within a short flight to the heart of Lower Manhattan. With a real or fake license, anyone can rent a small plane from these airfields and, under visual flight rules, fly below 1,100 feet to within a few miles of Manhattan before contact with the Federal Aviation Administration is required.¹¹⁷ The million dollar question is: would Combat Air Patrol fighter aircraft be able to identify and neutralize the threat before the pilot of the small aircraft could fly into a target with his RDD on board? Even with the millions of dollars already spent on counter-terrorism, the answer is most likely no ... the aircraft would probably reach its target. One needs to go back only to 12 October 2006 when New York Yankee pitcher Cory Lidle and his instructor pilot crashed into the side of a Manhattan apartment building after making a

¹¹⁵ "Secretary Chertoff's Remarks at the University of Southern California DHS Center of Excellence on Security in the 21st Century," Center for Risk and Economic Analysis of Terrorism Events, (Los Angeles, CA: 20 July 2007), On-line: http://www.dhs.gov/xnews/speeches/sp_1184959845456.shtm.

¹¹⁶ Ibid.

¹¹⁷ Julia Vitullo-Martin, "Operation Atlas And The Security Of New York," Gotham Gazette, 24 March 2003, On-line: <http://www.gothamgazette.com/article/issueoftheweek/20030324/200/322>.

distress call.¹¹⁸ What if this plane had been a terrorist with a RDD on board with the intent to strike a target in Lower Manhattan? The vulnerability to attack by a terrorist's small boat or aircraft is all too real and no ready fix is in sight.

Attack Planning

Assuming that the al Qaeda operative tasked by bin Laden to develop a RDD attack plan understood the wide availability of RDD materials and the vulnerability of U.S. targets, he would have all the key information necessary to build a plan with a reasonable chance of success to achieve the goal of creating a mass effect within the United States. What might an al Qaeda RDD attack plan include? Its specific elements would consist of deciding upon and securing materials, identifying and selecting potential targets, and choosing the methods of attack. Let us consider each step in their planning process.

Step 1: Radiation Source Selection

Of the hundreds of radioactive isotopes produced in a nuclear reactor, only a handful are considered by experts to be candidates for use in a RDD: americium-241, californium-252, cesium-137, cobalt-60, iridium-192, plutonium-238, strontium-90, and radium-226. Furthermore, due to persistence (relatively short half-lives in years versus days), strong radiation emission, and availability in commercial sealed sources, three isotopes are generally considered the most attractive: cobalt-60 (5.27 yrs), strontium-90 (29.1 yrs), and cesium-137 (30.17 yrs). Of the three, cesium-137 is a likely choice for use in a RDD.

Cesium-137 is a liquid at room temperature, however, it easily bonds with chlorides to form a crystalline powder.¹¹⁹ The powdered form is what is used in a majority of commercial

¹¹⁸ "Yankees pitcher killed in crash of small plane in Manhattan," CNN.com, 12 October 2006, On-line: <http://www.cnn.com/2006/US/10/11/plane.crash/index.html>.

¹¹⁹ "Radioisotope Brief: Cesium-137 (Cs-137)", Centers for Disease Control and Prevention, On-line: <http://www.bt.cdc.gov/radiation/isotopes/cesium.asp>.

products that utilize radioactive sealed sources. Because it is the most widely used isotope in commercial products; it is easily dispersible in powder form and readily attaches to soil, concrete, and building materials¹²⁰; and its radioactive emissions are both strong and persistent, cesium-137 is the prohibitive favorite to be used in a RDD.

Open source data backs up this conclusion. A Google search coupling cesium-137 with “dirty bomb” identified 6,730 hits, almost doubling the number of hits compared to a similar search using strontium-90 and six times greater than cobalt-60. The Goiania, Brazil real-world incident with cesium-137 showed just how easily the material can be dispersed and how difficult it can be to decontaminate an area.

Virtually all threat scenarios developed by government experts use cesium-137 in the construction of a RDD attack scenario. The most recent example was the October 2007 Top Officials 4 National Planning Scenario 11 Exercise that used cesium as the radioactive isotope in constructing the RDD attack scenario. Precisely because of its wide availability and ideal properties, the radiological material of choice to make a RDD is cesium-137. With the largest sources of cesium-137 located in medical facilities (blood irradiators) or food processing plants (sterilization and food irradiation), a terrorist cell could locate one or more of these units and acquire the sealed source either through bribing an insider, theft, or possibly using formal applications to fraudulently represent a licensed company authorized to acquire these machines. It should be noted that the attacker will likely have in his possession radiation detection equipment capable of identifying individual radioactive isotopes in order to authenticate the acquired material. Once in possession of cesium-137 to make a RDD, the next step is choosing a target.

¹²⁰ Noah Shachtman, “How Bad Can a ‘Dirty Bomb’ Be?,” (Wired, 10 June 2002), On-line: <http://www.wired.com/politics/law/news/2002/06/53110>.

Step 2: Target Selection

With a stated goal of achieving the greatest mass effect possible (great economic damage and psychological paralysis), the best suited targets likely will be located in densely populated urban areas with relatively high cost of living conditions. Additionally, shutting down a key economic node such as a financial district or transportation/supply hub; or targeting leadership or popular tourism locations are key secondary considerations. Target selection will depend on a number of planning factors to ensure the best chance of success. Operationally, al Qaeda understands that multiple independent targets struck simultaneously will greatly increase the probability of the desired mass effect. Just as the 9/11 attack utilized four airplanes, one of which was not successful, a RDD attack against multiple targets will increase the odds of achieving their goal. However, the amount of cesium-137 acquired and the location will determine if multiple attacks are feasible. For example, if 1,000 Curies of cesium-137 is procured, a choice would be made as to whether or not to separate the material to produce multiple RDDs or create just one large RDD. Additionally, as more and more major cities deploy radiation detection equipment such as NYC has done, the risk of transporting the material a long distance will increase the chance of detection, although circuitous roads are certainly available to circumvent traveling through major cities within the United States.

Ultimately, the target or targets selected might not be within NYC, based on NYC's effort to protect itself from a RDD attack. While it is likely that NYC represents the number one target choice, the probability of detection of the RDD before it can be employed is too great - the risk outweighs the reward. While Internet research on other major city's efforts to "harden" themselves from a RDD attack is not as well documented as NYC, there were some indications that Washington D.C, Chicago and Los Angeles are active in deploying initiatives such as

radiation detectors to thwart a possible RDD attack. Hardening a city is a resource intensive effort that not all cities are capable of undertaking presently, although the Domestic Nuclear Detection Office's goal is to deploy radiation detection equipment throughout the country.

The bottom line is that a terrorist will likely select a target primarily based on overall population, population density, cost of living index, and chance for success. Maximizing the first three and minimizing the latter could be the objective. Secondary considerations in selecting a city will be key critical infrastructure nodes such as U.S. iconic landmarks, economic hubs, or leadership sites. Utilizing this criteria, potential high value U.S. target cities are listed in Figure 3. Al Qaeda would likely weigh the aforementioned criteria against each city's level of protection to determine the targets that offer the best chance of success to achieve a mass effect.

Potential U.S. City Targets	2006 Population (within city limits) ¹²¹	2005 Population Density (per sq mi) ¹²²	2005 Cost of Living Index ¹²³
New York	8,214,426	26,402 ¹²⁴	212.1
Los Angeles	3,849,378	7,876	153.1
Chicago	2,833,321	12,750	128.6
Houston	2,144,491	3,371	90.2
Phoenix	1,512,986	2,782	98.2
Philadelphia	1,448,394	11,233	119.0
San Antonio	1,296,682	2,809	94.2
San Diego	1,256,951	3,771	141.0
Dallas	1,232,940	3,469	95.2
San Francisco	744,041	16,443	177.0
Boston	590,763	12,166	136.8
Washington D.C. ¹²⁵	581,530	9,070	137.8
Las Vegas ¹²⁶	552,539	4,154	109.8

¹²¹ "Top 50 Cities in the U.S. by Population, 2006," On-line: <http://www.infoplease.com/us/census/top-50-cities-2006.html> (accessed 27 January 2008).

¹²² "Demographics of the United States," Wikipedia, On-line: http://en.wikipedia.org/wiki/Demographics_of_the_United_States#Population_density.

¹²³ "Cost of Living Index for Selected U.S. Cities," On-line: <http://www.infoplease.com/ipa/A0883960.html> (accessed 27 January 2008).

¹²⁴ Manhattan as a subset of New York City has a population density of 66,173 per square mile coupled with extremely high real estate values, tourism, and economic nodes such as the financial district (Wall Street)

¹²⁵ Washington D.C. secondary considerations include tourism, iconic landmarks, and location of national leadership

Figure 3. Potential High Value U.S. City Targets for a RDD Attack

In the final analysis, any successful attack in a major city would likely create the desired mass effect with both economic and psychological impacts. Additional effects would be amplified if the terrorist publicly stated follow-on attacks are imminent even though they may not be.

Step 3: Selecting the Method of Attack

As previously pointed out, America is vulnerable to a small boat or aircraft attack. Assuming the attacker is willing to give up his life (e.g., the 9/11 attackers), the complexity of the plan is greatly reduced with no exit criteria necessary. A small plane, for example, loaded with conventional explosives and cesium -137 would have a high probability of reaching a target in a major city considering that flight would bypass all radiation detection equipment and other procedures to give warning and sound alarms.

Prior to the attack, it is likely the attacker will perform extensive reconnaissance in an attempt to determine the level of radiation detection capability in place. By using legal sources known to set off radiation detectors such as recent medical procedures involving radiation therapy in the body or the small amounts of americium-241 found in smoke detectors, an attacker could potentially scout transit routes. From the location where the material is acquired, to the location where the RDD is assembled, to the transportation routes associated with the method of delivery whether it is to the airport, waterway, or vehicle approach into a city, the al Qaeda operatives, if not stopped during multiple dry runs while carrying legal material, could be reasonably sure that U.S. radiation detection capability at that location is either inadequate or nonexistent.

¹²⁶ Las Vegas is included because it is the second most popular U.S. recreational location with 38.9 million annual visitors; additionally, Las Vegas Blvd real estate is one of the most expensive areas in the nation due to multi-billion dollar casinos

After acquiring a cesium-137 source, the attacker plausibly ought to require a means to shield himself from the radiation once the sealed source is broken and the RDD is constructed. To increase the chance of success, a terrorist cell probably would divide responsibilities among several members since the individuals constructing the RDD may very well receive a lethal dose of radiation from the moment the sealed source is broken up through the time it takes to construct the RDD and place it in a shielded container for transport to the delivery vehicle. Another cell member likely would then execute the attack. While a successful RDD attack could involve any number of delivery methods, the key is transporting the RDD to its target undetected and successfully executing the contamination attack.

Recommendations

Many who have looked at the availability of radiological materials and al Qaeda's stated intent, consider that the probability of a RDD attack on U.S. soil in the next ten years is high. The good news is the U.S. government recognizes the RDD threat and has implemented numerous initiatives to counter the threat. While taking steps in the right direction, more should be done to prevent a RDD attack. A dirty bomb attack, if successful, could devastate a large segment of the American economy and potentially could cost taxpayers billions to even trillions of dollars in remediation costs. The following recommendations are provided to focus effort on those initiatives that provide the greatest potential for securing the U.S. Homeland from a RDD attack. These recommendations are actions directed within U.S. borders. Counter-terrorism recommendations beyond U.S. borders such as installation of radiation detection equipment or addressing the security of radioactive sealed sources in foreign countries is important but are beyond the scope of this paper and are not addressed.

1. Expand / Fund the National Radiation Detection Network - Create a National C2 System

A key to preventing a RDD attack is detecting radioactive material in transit. The Department of Homeland Security and NYC “securing the cities” initiative provides a model for future defensive designs for high value targets. Layering an integrated radiation detection sensor network extending out 50 miles from Lower Manhattan provides a warning system and defense in depth, but only if the source can be interdicted before reaching its target. By placing radiation detection equipment at key transportation nodes and putting detectors on patrol vehicles and in the hands of patrolman, NYC has created a web of overlapping sensors to detect and interdict radiation sources. Tying the sensor network into a central coordination center provides the ability to quickly coordinate a NYPD interdiction response.

Expanding NYC’s concept nationally, while costly, would provide a major deterrent to the terrorist threat of locating, acquiring, and transporting an unauthorized radioactive material in the United States. The Domestic Nuclear Detection Office is making progress in deploying radiation equipment along the nation’s borders and at seaports and air terminals, however, this does not address the threat posed by any of the millions of sealed sources within the United States. The key to a national warnings and indicators alarm system for RDD threats would be a centralized command and control network capable of receiving timely information on unidentified radiation sources and having the means to immediately direct the closest response action to intercept the source. Specifically, the goal should be to develop a web-based system that connects every GPS-enabled radiation sensor to a wireless network that sends detection data to a centralized command center. The placement of sensors should focus on government vehicles that are in constant motion such as police patrol vehicles, as well as at key transportation nodes in and around major U.S. cities. Once the system is on line, every effort to

educate the population on this system should be made which would have two effects. First, the general population would feel safer knowing the government is actively combating a very real threat. Secondly, the risk of detection anywhere within the U.S. would provide a strong deterrent to the terrorist considering a RDD attack.

2. Provide Annual Oversight / Inspection of NRC's National Tracking System Performance

The passage of the 2005 Dirty Bomb Prevention Act requiring a national tracking system for radioactive sealed sources was a step in the right direction. The Nuclear Regulatory Commission followed up on 8 November 2006 by creating the National Source Tracking System to track Category 1 and 2 sealed sources. However, progress has been negligently slow to complete the effort to inventory all Category 1 or 2 sealed sources. Without a complete inventory, ensuring compliance with the requirement to physically verify and reconcile the National Source Tracking System annually is impossible. Transparency of movement is absolutely critical for all Category 1 and 2 sealed sources. Category 3 sealed sources should also be added to the tracking system since it is feasible that acquisition of multiple Category 3 sources could amount to enough material for a small but effective RDD. To do this, the Nuclear Regulatory Commission requires adequate funding for they must make the National Source Tracking System a priority effort. To ensure compliance with the Dirty Bomb Prevention Act, Congress should require the GAO to conduct annual inspections of the program to ensure both compliance and progress. An accurate sealed source U.S. inventory is the critical first step to ensuring the material is accounted for and properly disposed of when its useful life has ended.

3. Implement Stricter Approval Process for Purchase of Sealed Sources

Both the March 2003 GAO investigation and the July 2007 GAO investigation revealed gross security gaps in the ability of a front company to acquire radioactive material via formal

applications for material ostensibly to be used for legitimate purposes, masking their real intended use as RDD material. Assuming all sealed sources are accurately tracked and physically verified annually via the National Source Tracking System, the next critical measure is implementing a much stricter approval process for any company requesting a license. Mandatory in the approval process must be a physical visit to the company, a review of whether there is a legitimate business requesting the material, and whether that business requires radiological material to provide its products or services. Further, a face-to-face interview with the individual requesting the license should be part of the process. Additionally, a background check done by an appropriate federal agency to vet for possible criminal ties should also be mandatory. Following the approval of a license, a follow-up physical inspection within six months should be conducted to ensure the sealed source material is being used for its intended purpose and also to confirm that the licensed company is complying with all National Source Tracking System requirements.

4. Provide Incentives to Create Science & Technology Alternatives to Use of Sealed Sources

Since 2001, the Environmental Protection Agency through its Alternative Technologies Initiative has been working with industry to identify non-nuclear material to replace any of the 25 different radioactive isotopes used in industrial and medical devices.¹²⁷ Congress should aggressively fund this initiative and provide incentives to industry via tax breaks to cooperate in developing new technology to move this conversion quickly. The quickest path to building a RDD is acquiring an abandoned radioactive sealed source or stealing it from an inventory that historically has lax security and accountability. Diminishing the pool of available radioactive sealed sources is one of the more effective long term solutions.

¹²⁷ “Alternative Technologies for Industrial Applications,” U.S. Environmental Protection Agency, On-line: <http://www.epa.gov/radiation/source-reduction-management/alt-technologies.html>.

5. Provide an Extensive National Public RDD Education Program

Fear of radiation, as previously discussed, will likely cause psychological disorders as an after effect from a RDD attack. The Goiania, Brazil incident provides a real world case study that showed how the negative social stigma attached to the residents of Goiania following the accident was widespread. Many Goiania residents were turned away at neighboring hotels as well as having their cars stoned if they ventured beyond Goiania to other cities.¹²⁸ This reaction was directly correlated to the irrational psychological fears of radiation.

Should the United States suffer a RDD attack, wrong information, rumors based on fears, and threats of continued attacks might perpetuate and amplify negative psychological and economic effects beyond the immediate physical effects. However, with proper education on radiation, its effects, and how to protect themselves after a RDD attack, the American public could greatly reduce irrational fears of radiation if, in fact, a RDD attack occurred. In 2002, the U.S. National Academy of Sciences concluded that “education and training can serve an effective counter to future RDD attacks.”¹²⁹ Two positive outcomes would result. First, public resilience would be enhanced by building the ability to deal with the attack in an orderly and measured way, thus avoiding any tendency toward mass panic. This likely could save lives and reduce public anxiety. The public would understand the appropriate actions to take, whether remaining indoors or evacuating up wind. This, in turn, would help first responders perform their initial response actions. Secondly, realizing the elevated risk of cancer is slight, the public may be more willing to live in an area for an extended period of time with higher dose limits than the currently stringent 15 mrem/year EPA limits. Higher limits would provide time for

¹²⁸ “Radiological Agents of Terrorism,” Rutgers University and New Jersey Department of Health and Senior Services. On-line: http://njlmn.rutgers.edu/cdr/docs/Module04-radiological_agents.pdf (accessed 26 January 2008).

¹²⁹ Charles D. Ferguson and William C. Potter, *The Four Faces of Nuclear Terrorism*, 308.

decontamination efforts to work on exposed buildings, facilitating continued commerce, and preventing unnecessary demolition actions.

Educating the public will require repeated and consistent public service messages using radio, television, and the Internet. The target audience should be the citizens living in major U.S. cities. High-level government officials should consistently weave preparation actions into public speeches and interviews, steering the public to the web site www.ready.gov to learn more about preparing for emergencies. This website is useful but should be improved to make it easier to navigate to information on WMD attacks such as a RDD.

Additionally, www.ready.gov should allow people to register to receive automatic text messages on their cell phone in the event of an attack in their city which would provide key response actions to take immediately as well as follow up actions. The registration process would also provide a tool to track the effectiveness of the education by asking for feedback, as well as indicating how many people are acting on the educational messages. This, in turn, would help improve future educational campaigns. Media outlets should be prepared to guide the public.

In 2002, the U.S. National Academy of Sciences recommended developing and disseminating “prepackaged kits” to instruct local, state, and national media of key messages to address to the public in the event of a RDD attack.¹³⁰ A prepared media will be essential to calm the public and facilitate first responder actions.

Lastly, a robust and frequent exercise program within each major city is key to ensuring a high level of first responder readiness and keeping the threat in the forefront of the public’s mind. Exercising to prepare for managing the consequences of a RDD attack will also attract media coverage which can further educate the public.

¹³⁰ Ibid., 309.

Conclusions

Radiological weapons pose a serious threat within the United States. A successful RDD attack in a major U.S. city would not result in a high loss of life but could inflict many billions of dollars in direct economic damage and many times more in indirect damage to the U.S. economy and to U.S. and world capital markets as investor confidence would undoubtedly be shaken. For this reason, terrorists are likely pursuing a RDD.

This paper indicates that even though they only had access to the Internet and a public library, a terrorist organization still could gather an abundance of information on RDDs. Armed with a better understanding of radiation, its effects, potential radioactive sources and acquisition methods, as well as efforts by the United States at all levels of government to prevent and respond to a RDD attack, a terrorist organization would be able to exploit vulnerabilities and build an attack plan with a reasonable chance of success. Implementing the recommendations in this paper would be a good start to minimizing these vulnerabilities.

America has made much progress since September 11, 2001 in protecting its homeland from terrorist acts. However, America must not become complacent. Recognizing the very real RDD threat and remaining resolute to confront this threat by protecting critical U.S. targets must remain a top priority.

Bibliography

Allison, Graham. *Nuclear Terrorism: The Ultimate Preventable Catastrophe*. New York, NY: Henry Holt and Company, LLC, 2004.

Aloise, Gene. *Combating Nuclear Terrorism: Federal Efforts to Respond to Nuclear and Radiological Threats and to Protect Key Emergency Response Facilities Could Be Strengthened*. Washington D.C.: United States Government Accounting Office, GAO-08-285T, November 2007. <http://www.gao.gov/new.items/d08285t.pdf>.

Brown, Chad. "Transcendental Terrorism and Dirty Bombs: Radiological Weapons Threat Revisited." Air University. Maxwell Air Force Base, AL, February 2006. <http://www.au.af.mil/au/awc/awcgate/awccsat.htm>.

Combating Nuclear Smuggling: Challenges Facing U.S. Efforts to Deploy Radiation Detection Equipment in Other Countries and in the United States. Washington D.C.: United States Government Accounting Office, GAO-06-558T, 28 March 2006.

Dunn, Lewis A. *Can al Qaeda Be Deterred from Using Nuclear Weapons?*. Washington, D.C.: Center for the Study of Weapons of Mass Destruction, National Defense University, July 2005.

Falkenrath, Richard A. *Prepared Statement of Testimony Before the Committee of Homeland Security and Governmental Affairs: US Senate*, 12 September 2006.

Ferguson, Charles D., and William C. Potter. *The Four Faces of Nuclear Terrorism*. New York, NY: Routledge, 2005.

"Handbook for Responding to a Radiological Dispersal Device: First Responder's Guide - The First 12 Hours," Conference of Radiation Control Program Directors, Inc., CRCPD Publication 06-6, September 2006. www.crcpd.org.

Homeland Security Presidential Directive / HSPD-8 - National Preparedness, Washington D.C.: The White House: Office of the Press Secretary, 17 December 2003.

International Atomic Energy Agency. "International Atomic Energy Agency Safety Standard Series No. RS-G-1.9: Categorization of Radioactive Sources." Vienna, Austria: IAEA Publishing Section, August 2005. http://www-pub.iaea.org/MTCD/publications/PDF/Pub1227_web.pdf.

International Atomic Energy Agency. "Sealed Radioactive Sources: Uses and Risks." Vienna, Austria: Issues for Government Agencies. http://www.iaea.org/Publications/Booklets/SealedRadioactiveSources/government_uses.html (accessed 26 January 2008).

Kaplan, Eben. "New York Spurs Counterterrorism Efforts," *Council on Foreign Relations*, 28 December 2006.
http://www.cfr.org/publication/12312/new_york_spurs_counterterrorism_efforts.html.

Keller, Bill. "Nuclear Nightmares." *New York Times Magazine*, May 26, 2002, 22-57.

Looney, Robert. "Strategic Insight: Economic Costs to the United States Stemming From the 9/11 Attacks". Monterey, CA: Center for Contemporary Conflict, Naval Postgraduate School, 5 August 2002.
<http://www.ccc.nps.navy.mil/rsepResources/si/aug02/homeland.asp>.

Lugar, Richard G. "The Lugar Survey on Proliferation Threats and Responses," Washington D.C.: Senator Richard G. Lugar - Chairman, Senate Foreign Relations Committee, June 2005. <http://lugar.senate.gov/reports/NPSurvey.pdf>.

Medalia, Jonathan. *Terrorist "Dirty Bombs": A Brief Primer*. Washington D.C.: Congressional Research Service Report for Congress RS21528, Library of Congress, 29 October 2003.

Miner, Glenn. "New York State Police, Homeland Security Office Launch Upstate Radiological Security Program," New York State Office of Homeland Security, Division of State Police, 18 September 2007.
http://www.security.state.ny.us/ohs_press_releases/Rad%20Detection%20program%209-18-07.pdf.

Nuclear Security: Federal and State Action Needed to Improve Security of Sealed Radioactive Sources. United States Government Accounting Office. Washington D.C. GAO-03-084. August 2003.

O'Hanlon, Michael E., Peter R. Orszag, Ivo H. Daalder, I.M. Destler, David L Gunter, James M. Lindsay, Robert E. Litan, and James B. Steinberg. *Protecting the American Homeland*. Washington D.C.: Brookings Institution Press, 2002.

Pacific Northwest National Laboratory. "Thinking about the Unthinkable: Economic Consequences of a Nuclear Attack," Richland, WA: Environmental Technology Directorate, 27 January 2006.
http://environment.pnl.gov/accompproline/prodline_detail.asp?id=540.

PBS. "Dirty Bombs Transcript." Nova, 25 February 2003.
http://www.pbs.org/wgbh/nova/transcripts/3007_dirtybom.html.

Rosoff, Heather. and von Winterfeldt, Detlof.. "A Risk and Economic Analysis of Dirty Bomb Attacks on the Ports of Los Angeles and Long Beach." *Risk Analysis* 27, no. 3 (2007): 533-546.

Shea, Dana A. *Radiological Dispersal Devices: Select Issues in Consequence Management*. Washington D.C.: Congressional Research Service Report for Congress RS21766, Library of Congress, 7 December 2004.

Silber, Mitchell D. and Arvin Bhatt, "Radicalization in the West: The Homegrown Threat," New York City Police Department, Intelligence Division, 2007.
http://www.nyc.gov/html/nypd/downloads/pdf/public_information/NYPD_Report-Radicalization_in_the_West.pdf.

Sudnik, John. "Dirty Bomb Attack: Assessing New York City's Level of Preparedness from a First Responder's Perspective." Master's thesis, Monterey, CA: Naval Postgraduate School, March 2006.

The 9/11 Commission Report. *National Commission on Terrorist Attacks Upon the United States*. Washington, DC: US Government Printing Office, July 2004.

The National Strategy for The Physical Protection of Critical Infrastructures and Key Assets. Washington D.C.: US Government Printing Office, February 2003.

US Department of Defense. *Report of the Defense Science Board Task Force on Preventing and Defending Against Clandestine Nuclear Attack*. Washington D.C.: Office of the Under Secretary of Defense for Acquisition, Technology, and Logistics, June 2004. (Muir S. Fairchild Research Center, Call number M-U 40607-177).

US Department of Defense. *Strategy for Homeland Defense and Civil Support*. Washington D.C.: Department of Defense, June 2005.

US Department of Homeland Security. *National Strategy for Homeland Security*. Washington D.C.: Department of Homeland Security, October 2007.

US Department of Homeland Security. "Preventing the Entry of Weapons of Mass Effect Into the United States." Washington D.C.: Homeland Security Advisory Council: Weapons of Mass Effect Task Force, 10 January 2006. http://www.dhs.gov/xlibrary/assets/hsac_wme-report_20060110.pdf.

US Department of Homeland Security. "Ready: Prepare. Plan. Stay Informed." Washington D.C.: Ready Campaign. <http://www.ready.gov/america/index.html> (accessed 26 January 2008).

US Department of Homeland Security. "TOPOFF 4 Frequently Asked Questions," Washington D.C.: Preparedness and Response.
http://www.dhs.gov/xpreprep/training/gc_1179422026237.shtm (accessed 26 January 2008).

US Senate, *Dirty Bomb Vulnerabilities: Staff Report to Permanent Subcommittee on Investigations*. Washington D.C.: Committee on Homeland Security and Governmental Affairs, 12 Jul 2007.
http://hsgac.senate.gov/_files/REPORTDIRTYBOMBVULNERABILITIESFINAL.pdf.

Wahlert, Matthew H. and Shane Tomashot. "Protecting the Super Bowl: The Terrorist Threat to Sporting Events." In *Homeland Security: Protecting America's Targets*, edited by James J. F. Forest, 163-188. Westport, CT: Praeger Security International, 2006.

Zimmerman, Peter D. and Cheryl Loeb. "Dirty Bombs: The Threat Revisited." *Defense Horizons*, no. 38 (January 2004): 1-11.